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SEDIMENT AND BIOLOGICAL ASSESSMENT OF CANAGAGIGUE CREEK AT THE UNIROYAL CHEMICAL LTD. PLANT ELMIRA, ONTARIO 1995-96

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SEDIMENT AND BIOLOGICAL ASSESSMENT OF CANAGAGIGUE CREEK AT THE UNIROYAL CHEMICAL LTD. PLANT ELMIRA, ONTARIO 1995-96

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Executive Summary

In June 1995, an initial investigation into sediment contamination in Canagagigue Creek, adjacent to the Uniroyal Chemical Ltd. plant at Elmira was undertaken. Sediments were sampled upstream and downstream of the site, including one site on the floodplain with the most intensive sampling undertaken adjacent to the Uniroyal property. Additional samples were collected in October and November and included one site on the floodplain approximately 1.5 km below the Uniroyal site.

Sediments were analyzed for a large number of compounds. The concentration of these compounds in sediment were compared to sediment guidelines where these were available. In the case of dioxins and furans, concentrations were compared to draft guidelines as well as to concentrations in other areas where contaminated sediments have been found.

DDT (and metabolites DDD and DDE), some dioxins and furans (primarily 2,3,7,8-tetrachlorodibenzo-p-dioxin (T_4CDD)) and Polycyclic Aromatic Hydrocarbons (PAHs) were found at elevated concentrations in creek sediments adjacent to the Uniroyal Chemical Ltd. site. None of these compounds were detected in sediments upstream of the plant. PAHs were found at higher concentrations immediately downstream of Shirt Factory Creek, a tributary of Canagagigue Creek, and appear to originate from the Elmira urban area.

DDT (and metabolites) and dioxins and furans appeared to originate from the plant site. Concentrations of both were highest in sediments adjacent to the plant. The southwest part of the property had the highest sediment concentrations of both groups of compounds. Sediment concentrations of DDT, DDD and DDE exceeded the Provincial Sediment Quality Guidelines (PSQGs) at a number of locations. Dioxins and furans, primarily 2,3,7,8-T_4CDD, exceeded the draft No Effect Level of the PSQGs at nearly all locations adjacent to, and downstream of, the property. While other dioxin/furan guidelines are currently not available, comparison of sediment concentrations with other areas inside and outside the province, indicates these are among the higher levels detected in sediment.

The full extent of the contamination could not be determined on the basis of the initial investigation undertaken in 1995. The biological effects associated with the elevated levels were also not known. As the sediment concentrations of DDT, DDD and DDE exceeded the severe effect level, the "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" required sediment bioassay tests be conducted to assess whether the sediment is acutely toxic to aquatic life. As the sediment concentrations of dioxins and furans exceeded local background values, the guidelines require a number of biological assessment techniques be used to determine if the sediment poses a threat to aquatic life and if so, the severity of that effect. The assessment of the biological effects in turn permits management decisions to be made on the need and potential effectiveness of available remediation options including source control and sediment remediation.

Based on the findings of the 1995 study and the requirements of the sediment quality guidelines, a follow-up study was undertaken in 1996. The objectives of the 1996 investigation were to further delineate the extent of the contamination and to determine the severity of the contamination based upon effects on aquatic life. The 1996 sediment investigation involved the collection of sediments on two separate occasions in May and again during a two day period from Sept. 30 to Oct. 01. Samples for benthic community structure analysis were collected in June 1995 and May 1996. Sediments for Bioassay testing were also collected in May 1996.

The results of the sediment investigations indicate that sources on the Uniroyal site have contributed to contamination of sediments along both sides of the creek, from the impoundment area to the Grand River. Contaminant levels are highest on the Uniroyal property, and contaminants appear to be focused in fine sediments in depositional areas. Exposed bank areas of the creek on the Uniroyal property are also contaminated with DDT and dioxins and furans.

Sources of DDT compounds are indicated in the impoundment area, and immediately downstream in the small west channel. The former waste pits are strongly implicated as sources of DDT and dioxins and furans. Once in the creek, the material becomes focused in depositional areas, with the highest concentrations close to the source, on the Uniroyal property, and lower concentrations downstream. There is also a suggestion that flow from Shirt Factory Creek has carried DDT compounds to Canagagigue Creek. In addition, some DDT may also have been transported with contaminated groundwater in the west channel, at and below the former waste lagoons.

Sources of dioxins are indicated in the impoundment area for 2,3,7,8-T_4CDD, below the 0400 discharge for OCDD, and along the west channel, again for 2,3,7,8-T_4CDD. The increase in concentrations of 2,3,7,8-T_4CDD with depth, particularly in areas characterized as erosional, strongly suggests that groundwater has and may continue to act as a transport mechanism. The depth and degree of contamination of these sediment indicate they will continue to act as a source of contamination to downstream areas through erosion.

Many areas of the banks on both sides of the creek appear to be contaminated with 2,3,7,8-T_4CDD, as well as DDT compounds, and may reflect resuspension of creek sediments and subsequent deposition in bank areas during high flow conditions. In the creek, the dioxins appear to be deposited in quiescent areas, with the highest concentrations found on the Uniroyal property. Detectable levels, though relatively low, were found as far downstream as the Grand River.

Areas of the floodplain appear to be contaminated with both DDT compounds and dioxins and furans. A number of permanent and temporary ponds were sampled, and all had elevated levels of both groups of compounds when compared to upstream locations. The annual flooding of the creek is the most likely mechanism of transport to these areas.

The benthic communities in depositional areas of the creek were observed for effects of contaminants on benthic community structure. Direct effects of contaminants on benthic community health could not be determined. The primary concern related to elevated contaminant concentrations appears to be bioaccumulation and biomagnification of these compounds through the food chain. This does have direct implications on human consumers of fish from the creek, since carp have been found to have unacceptably high tissue levels of dioxins.

The process outlined in the sediment quality guidelines has been used to determine that large areas of the creek have sediments with elevated levels of dioxins and furans, as well as DDT compounds in excess of the severe effect level. Despite the elevated concentrations of these compounds there is no direct toxicity associated with these levels in the laboratory. There is however, a suggestion of reduced biological diversity in the field in those areas where DDT compounds were in excess of the Severe Effect Level. Biological testing has also found, that the compounds are bioavailable and can potentially move up the food chain. Therefore, there are biological effects associated with the contaminant levels.

The ministry's recommendations for subsequent action have been identified in Section 6.0 of this report. The recommendations for subsequent action are based upon the need to control sources before additional action is undertaken through a remediation plan.

1.0 INTRODUCTION

In June 1995, the Environmental Monitoring and Reporting Branch (EMRB) of the Ontario Ministry of the Environment and Energy (OMOEE) undertook a preliminary sediment investigation of Canagagigue Creek at the Uniroyal Chemical Ltd. site in Elmira. The results of the study (Jaagumagi & Townsend 1996) determined that parts of the site, as well as downstream areas of the creek, were contaminated with DDT compounds and dioxins and furans. A study conducted concurrently by Hayton and Petro (1996) indicated that a number of persistent compounds, such as DDD and DDE, and dioxins and furans, have been accumulated by mussels and leeches.

The 1995 study found elevated concentrations of DDT and the metabolites DDD and DDE in creek sediments, beginning at the dam impoundment area on the Uniroyal Chemical Ltd. property. Concentrations in the impoundment, and at a number of sites downstream adjacent to the property, exceeded the Severe Effect Level of the Provincial Sediment Quality Guidelines (Persaud *et al.* 1993).

Concentrations of DDT and metabolites were generally higher in the deeper sections of the sediment. Since a number of these stream areas are erosional, higher concentrations at depth could most readily be explained through movement of DDT with solvents in the groundwater (DDT and metabolites are hydrophobic and would not move with groundwater alone).

The 1995 study also found that deeper layers of the sediment generally had higher concentrations of DDT than concentrations of DDD or DDE. The predominance of DDT suggests that much of the material was not weathered, since DDT can be readily biotransformed to DDD and DDE.

Concentrations of these compounds were higher in sediments along the west channel than in locations along the east side of the creek. Elevated levels persisted downstream as far as station 22 and suggest that sediment from adjacent to the Uniroyal property is being eroded and deposited in downstream areas.

Elevated levels of dioxins, especially 2,3,7,8-T_4CDD, were also found in creek sediments adjacent to the Uniroyal property. Core samples showed that concentrations of dioxins/furans in deeper layers of the sediment were approximately 4 times higher than in surficial layers. Since most of the areas where cores were obtained were erosional, the higher levels could be explained through movement of the compounds with solvents in groundwater.

Bed sediments in the west channel had higher concentrations of 2,3,7,8-T_4CDD than surficial fine sediments, while downstream of the property, surficial fine sediments yielded higher concentrations. This pattern suggests that erosion is occurring from upstream areas with subsequent deposition downstream.

There appeared to be an additional source of T_4CDD and T_4CDF upstream of station 0+397 (east) and 0+406 (west). This area required further investigation to determine the possible source of the higher T_4CDD and T_4CDF concentrations in sediment and was one of the areas targeted for the 1996 study.

High levels of some dioxins, particularly 2,3,7,8-T_4CDD, were found in a pond on the floodplain located approximately 1.5 km downstream of the plant. The elevated concentrations at this station suggested there may be contamination of areas of the floodplain, in addition to contamination of creek sediments. This area was targeted for further investigation in order to confirm these findings and to determine the extent and degree of contamination.

Comparison of 2,3,7,8-T_4CDD concentrations in sediment with other areas both within and outside of Ontario suggested that levels were high enough to be of concern. These levels also suggested that bioaccumulation could be a concern and additional biological testing was warranted.

Comparison of the individual congener group isomer patterns suggested that dioxin and furan contamination in the creek was originating from sources on the Uniroyal Chemical Ltd. property.

Concentrations of other contaminants, such as chlorophenols, chlorobenzenes and most metals were either below detection limits, or low (metals) and did not constitute a concern.

Based on the findings of the 1995 study, a follow-up study was undertaken in 1996 to further

delineate the extent of the contamination and to determine the severity of the contamination based upon effects on biological components.

The 1995 study included a number of recommendations for additional studies and these have been summarized below. In addition, concerns were raised by members of the public (through APTE) and additional work was undertaken to address these. The 1995 study recommended:

1. *Biological studies, using benthic organisms to measure uptake of contaminants directly from sediment, as well as measurement of toxic effects, would be warranted given the exceedance of SELs for DDT and metabolites, and the elevated levels of some dioxins and furans.*

   Rationale:

   The sediment assessment procedure outlined in the Provincial Sediment Quality Guidelines (Persaud *et al.* 1993) requires that biological assessment be undertaken where there are exceedances of the Severe Effect Level. The need for management action, including remediation, is not based on chemical criteria alone, but rather, upon the severity of biological effects determined as part of the biological assessment. The high concentrations of some of the dioxins, most notably 2,3,7,8-T_4CDD, the most toxic isomer, would also warrant additional biological investigation.

2. *Additional sediment sampling should be undertaken to determine the source of the high concentrations of 2,3,7,8-T_4CDD at station 0+397 (east) and to more accurately define the area and depth of contamination adjacent to the Uniroyal property.*

   Rationale:

   Investigation to determine the source of the high concentrations of 2,3,7,8-T_4CDD at station 0+397 should be undertaken since at present it is unclear whether these levels are due to seepage with groundwater, or deposition from upstream areas. Additional sediment investigation should be undertaken along the west side of the creek, upstream from station 0+397 to determine whether the contaminants are originating from this section of the creek. The creek bed sediments should be investigated in more detail to determine the full extent of contamination and provide a map of sediment contamination.

3. *Sediments/soils downstream of the Uniroyal site should be sampled for contaminants, and a map of contaminant concentrations in the creek and floodplain should be developed to guide any potential remedial action.*

   Rationale:

   Downstream areas of the floodplain have indicated the presence of high levels of both dioxins and DDT. These areas should be investigated to determine whether the contamination at the pond located at station 21 is an isolated occurrence or whether there is broader contamination of the floodplain. The elevated concentrations of DDT and metabolites in creek sediments downstream of the Uniroyal property should be more accurately defined.

The 1995 study also pointed towards a number of additional study components that needed to be addressed in order to gain a clearer understanding of the extent of contamination on the Uniroyal property as well as downstream. These included:

1. *Additional study is required on the east side and on the northwest side.*

2. *Sediment samples should be collected from the Grand River at the point of the Canagagigue Creek discharge.*

   Recommendation number 2 was not acted upon. The high flows experienced in the Grand River on a seasonal basis would result in rapid and wide-spread dispersal of sediments carried by Canagagigue Creek.

The additional sediment and biological assessment undertaken in 1996 was divided into 3 phases.

1. Additional sediment sampling based on new information and confirmation of previous information. Further sediment sampling was considered necessary to more accurately deter-

mine the areal extent of sediment contamination. Since the 1995 study, a number of potential seepage areas have been identified through sampling of groundwater by Conestoga-Rovers & Associates (CRA) (1996). In addition, a number of areas where additional sampling was needed were identified in the 1995 study.

a. An additional 10 locations on the Uniroyal property were sampled. This included a number of locations along the east side of the creek. Where possible, core samples were collected in these areas to determine the levels of contaminants in both the surface and sub-surface sediment.

b. In addition to sediment samples, bank samples at various locations on the Uniroyal property were collected for analysis. Since bank soils represent potentially erodible material, this would serve to indicate the quality of material that could be expected to find its way into the creek during higher flows.

2. Since sediment sampling undertaken in 1995 determined the potential for contamination of the floodplain, this area was targeted for more detailed investigation to determine the extent and degree of contamination.

a. A total of 12 core samples, from below the Floradale dam to the Grand River, were collected from permanent or temporary ponds on the creek floodplain for chemical characterization. Where possible, the cores were sectioned to determine if differences have occurred in deposition rates. The core samples would also serve to provide an indication of how far downstream contamination may extend.

b. At selected locations soils adjacent to the floodplain ponds were sampled. As well, water samples were collected from 2 locations (FP-3 and FP-7) where the ponds appeared to be of a more permanent nature, to determine concentrations of dioxins and furans in the water column.

3. Since sediment contamination has been confirmed, biological investigations are required to determine the severity of the contamination, and hence, the need for sediment remediation.

a. Sediment Bioassays. Sediment bioassays were conducted using standard Ministry protocols. Sediments were collected at 6 sites (1 upstream control (station 0+30), 3 locations on the Uniroyal property (stations 0+244, 0+630W and 0+750), and 2 locations downstream, both in the creek (station 21) and on the floodplain (station FP-3). Sediment would be tested for acute and chronic effects on benthic organisms (chironomids and mayflies), and for bioaccumulation from the water column (fathead minnows).

b. In-situ organisms were collected for tissue residue analysis. This type of analysis would provide an indication of what contaminants are directly available from sediment to sediment-ingesting biota. Biota (preferably chironomids and/or oligochaetes) would be collected at approximately 5 sites (1 upstream control, 3 locations on-site, and 1 location downstream in the floodplain). Tissues would be analyzed for DDT compounds and dioxins and furans. Analysis for DDT compounds requires approx. 5 gms of organisms, while for analysis of dioxins and furans a minimum of 10 gms would be required. The choice of which analysis was performed would be determined partly on the basis of the contaminant of concern at that particular sampling location and partly on the availability of sufficient biomass of organisms.

c. Benthic community structure samples were collected at each sediment sampling location in 1995 and 1996. Except for a few locations, stations sampled in 1995 were not re-sampled in 1996. Benthic samples were used to characterize benthic communities as a measure of stream health. This would be particularly useful in terms of long-term monitoring after the containment system becomes fully operational. The samples collected in 1995 and 1996 would form the baseline for conditions prior to the operation of the Upper Aquifer Containment System on the Uniroyal Chemical Ltd. site.

The biological evaluation of sediment contamination was designed to determine whether there were direct biological effects on aquatic organisms. The design of the sampling program was based on the methodology described in detail in Jaagumagi and Persaud (1996).

2.0 METHODS

Sediments were sampled on three separate occasions during 1996 (May 14, May 27-29, and Sept 30-Oct 1). The sediment survey of floodplain areas was conducted in May 1996.

On May 29-31, 1996, sediment sampling of additional and repeat locations was undertaken. Sediment bioassay samples for laboratory testing were also collected at this time.

A third set of sediment samples was collected in September and October of 1996. During this sampling period, tissue residue samples were collected at selected sites. Water samples for dioxin and furan analysis were also collected from 2 ponds located on the floodplain.

During each sampling period in 1995 and 1996, sampling commenced at the downstream end of the Uniroyal Chemical Ltd. site. Sample collection was performed in an upstream progression to avoid contaminating areas to be sampled. Sampling equipment was rinsed with creek water between samples and locations. The extremely hydrophobic nature of the contaminants of concern suggested that the possibility of transfer of sediment-bound contaminants, through desorption from the sediment, was extremely low and additional rinsing methods using hexane would be of little additional benefit.

2.1 Field Sampling

Sediment

Locations sampled in 1995 are presented in Figures 1 and 2. The location of sampling sites for the 1996 study are presented in Figure 3. Wherever possible, core samples were collected. However, the shallow depth of surficial sediments and presence of loose, unconsolidated sands and gravels, usually within the top 10-15 cm, precluded core sampling in many areas. In these areas, an Ekman grab sampler was used to sample surficial sediment (the sampler was pushed into the sediment by hand).

At each location, three replicate Ekman samples were collected, the top 5 cm removed and these were combined to form a single sample. Sub-samples were collected from the middle of the sample where sediment did not come into contact with the sampling device. The sample was homogenized in a stainless steel container and collected into appropriate sample jars for metals, nutrients, PCB, organochlorine pesticides, chlorophenols, chlorobenzenes, PAH, and dioxin/furan analysis. In shallow areas, such as Shirt Factory Creek, surficial sediment samples were collected directly into the stainless steel container, homogenized and placed in sample jars.

At locations where sampling was possible with a core sampler, three replicate cores were collected and sectioned into similar sections. The depth of the sections and the number of sections varied, depending on the depth of the core and the presence of visible discontinuities. The corresponding sections were combined and homogenized and placed in sample jars for analysis of the above list of parameters.

Where creek bed sediments could not be obtained with either a core or Ekman sampler due to presence of hard substrate, samples were collected by hand (shovel). In this case, 3 replicates were collected and subsamples taken from the area not in contact with the sampling device.

Details of sampling methods and locations are provided in Tables 1.1 to 1.3 for the 1995 sampling and Tables 2.1 and 2.2 for the 1996 sampling. The type of sampler used, and the depth of sampling are provided in these tables.

Stream Bank Samples

In addition to creek bed samples, sediment samples were also collected at various locations along the bank of the creek. Samples were collected to determine levels of contaminants in potentially erodible material. Bank samples were typically collected from the exposed bank during low water, such that the area sampled was between the low

water and high water levels. Where possible, samples were collected in those areas where little or no vegetation was encountered, since these areas would have greater potential erodibility.

Samples were collected with a 5cm diameter clear plastic (Lexan) core tube. The core tube was forced down vertically into the soil or sediment (by hand) until refusal. The sample was retrieved and the depth of sediment determined before the sample was extruded. Three replicate cores were collected at each location, sectioned into similar sections (length and number of sections was based on the length of the core), and the corresponding sections from each replicate combined into one sample. The sample was homogenized and a subsample of the homogenate was collected into sample containers for chemical analysis. Sampling locations are shown on Figure 4.

Where cores could not be obtained, samples were collected by hand with a spade. In these cases, a hole was dug until refusal, with the sides of the hole maintained as near vertical as possible. Samples were collected from the vertical face of the exposed soil/sediment horizon, composited, and placed in sample containers for analysis. Sampling locations and methods are described in detail in Tables 2.1 and 2.2.

Floodplain Sampling

Sediments:

Sediments were collected with a 5 cm diameter Lexan core tube where possible. At a few locations gravel/cobble substrates were encountered within 10 cm of the surface, and at these locations sediments were sampled by hand (i.e., shovel). In these cases, the sample collection procedure described above under Bank Samples was followed. Sample locations are shown on Figure 5.

Three replicate samples were collected at each location. Cores were sectioned on the basis of measured depth, the three sections were combined and homogenized, and a sample of the homogenate was retained for analysis. Details of sampling methods and locations are provided in Table 3.

Water:

Water samples were collected at 2 locations: FP-3 and FP-7 on October 1, 1996 (Figure 5). Two sets of samples were collected at each location. The first set was an undisturbed water sample, while the second set was collected after the sample collector had walked about in the pond, resulting in resuspension of bottom sediments. The latter was intended to simulate resuspension due to cattle movement. Both sets of samples were analyzed separately. Details of sampling methods and locations are provided in Table 3.

Benthic Community

Samples for benthic community structure analysis were also collected at the sediment sampling locations (Figure 6)(Tables 1.1 to 2.2). At those locations where samples were collected in 1995, additional samples were not collected in 1996.

Samples were collected with a 12" x 12"stainless steel Ekman grab. Riffle samples (1995) were collected with a 12" x 12" Surber sampler. Three replicate samples were collected at each location. Samples were washed in a U.S. #30 mesh (595u) sieve and the sample residue was preserved in neutralized (with sodium borate) formalin (10%) solution. Samples were sorted from debris in the laboratory using dissecting microscopes, and organisms were identified to the lowest practical taxonomic level.

Sediment Bioassay Testing

Sediments for testing were collected with a stainless steel Ekman grab sampler on May 27-29, 1996. The sampler was pushed into the sediment, and the entire sample was placed into a plastic 20l pail lined with polyethylene. Typically, 5 Ekman samples were required to obtain approximately 10-15 L of sediment. In some locations the presence of rock/gravel close to the surface required collection be undertaken with a shovel. The samples were transported to the Toronto, Ontario, laboratory where they were stored at 4°C until required.

A reference control sediment was sampled at a location upstream of the study area (station 0+30). Three locations were sampled on the Uniroyal site (stations 0+244, 0+630W, and 0+750), and two locations were sampled approximately 1.5 km

downstream both in the creek (station 21) and in a pond on the floodplain (station FP-3). The reference sediment should be representative of naturally occurring background contamination levels for the study area and be physically similar to the test sediments to help discriminate effects due to physical or chemical causes.

Sediment collected from Honey Harbour in Georgian Bay, Ontario, served as a negative control for each bioassay. The negative control sediment is a relatively uncontaminated sediment that provides a measure of test acceptability. Both control sediments are a basis for comparing the biological responses from the test sediments.

Tissue Residue Analysis

Benthic organisms were collected at three locations for tissue residue analysis of dioxins and furans. The locations sampled were stations 0+732 (west), 0+565 (west) and a control located in Bolander Park (upstream of 0+30). Sufficient sample biomass could not be obtained at the other planned locations.

At each location approximately 10 gms of organisms were collected. Since sufficient biomass of chironomids or oligochaetes could not be obtained, nymphs of the dragonfly family Libellulidae were selected. Dragonfly larvae were chosen as a suitable organism since they are predators on other smaller organisms, including sediment dwelling species. Since dioxins and furans are known to biomagnify through the food web, most of the body burden of the prey organisms should be transferred to the predator. In addition, these organisms spend up to two years in the water in the nymphal stage and thus provide a much longer time period for bioaccumulation.

Tissue samples were placed wet onto aluminum foil and frozen until analysis.

2.2 Analytical Methods

All sediment samples were submitted for chemical analysis to the OMOEE laboratory in Etobicoke. OMOEE analytical methods used for sample analysis are presented in Table 4. The samples collected in 1995 were analyzed for the following parameters: metals, nutrients, PCBs, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, chlorophenol, chlorobenzenes, particle size characterization and dioxins and furans. The 1996 samples were analyzed for a reduced set of parameters (total organic carbon (TOC), PCBs and organochlorine pesticides (includes DDT and metabolites) and dioxins and furans). The other parameters were dropped since the 1995 analysis showed no reason to continue analysis for these parameters.

Guidelines for the parameters tested, with the exception of dioxins and furans, are tabled in "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" (Persaud *et al.* 1993). An excerpt appears in Appendix A of this report. Currently, only draft guidelines for dioxins and furans for the No Effect Level (Appendix A) have been developed. Lowest Effect Level (LEL) and Severe Effect Level (SEL) guidelines are not yet available.

2.3 Laboratory Biological Testing Methods

Basic Experimental Design

Sediment biological tests were conducted according to OMOEE standardized procedures (Bedard *et al.*, 1992), and are briefly described below. The bioassays were static, single-species tests using whole-sediment. The experimental unit was a 1.8 L test chamber containing prepared sediment and dechlorinated municipal tap water (1:4, v:v). The chambers were randomly situated in a fumehood, at ambient room temperature and maintained under a natural photoperiod, and with continuous aeration.

Moist field-collected sediment (top 0-8 cm) was pressed through a 2-mm stainless-steel sieve to remove existing large biota and debris prior to use. Sieving was done under a fumehood on May 29-30, 1996. Subsamples of this homogenized sediment were submitted for chemical and physical characterization according to standard OMOEE procedures, as those previously described for the field samples. The sieved sediment was homogenized with a spatula and stored in 4 L acid-rinsed glass jars

until required. Three hundred and twenty-five millilitre aliquots of homogenized sediment were placed into the test chamber and overlaid with the test water. After settling overnight, the chambers were aerated continuously until the termination of the test. A clean, negative control sediment, collected from Honey Harbour, Georgian Bay, was used for each bioassay. Control mortality must not exceed 15% for mayflies and fathead minnows and 25% for chironomids or the test is declared invalid.

Water in the exposure chambers was regularly monitored for pH, conductivity, total ammonia, un-ionized ammonia and dissolved oxygen. Dead organisms were removed and the numbers recorded on a daily basis. Any signs of abnormal behaviour of the test organisms or changes in appearance of the test chambers were noted. Water loss due to evaporation was replenished as needed.

Hexagenia limbata Lethality and Growth Assay

The tests used 4 month old laboratory reared mayfly nymphs with an average wet weight of 5.21 mg $\pm$ 0.36 (s.e.) (n=27). The nymphs were raised from eggs collected by Dr. J. Ciborowski at the University of Windsor, Windsor, Ontario. Mayflies were reared according to OMOEE procedures (Bedard *et al.*, 1992) and methods described in the literature (Friesen, 1981).

The rearing procedure involved the transfer of 600 newly-hatched nymphs to a 6.5 L aquarium which contained 2 cm of autoclaved sediment and 5.6 L dechlorinated tap water. Animals were maintained at ambient room temperature under a 16:8 hour, light:dark photoperiod with constant aeration and fed a vegetable diet.

Test organisms were retrieved from the rearing aquaria by sieving small portions of sediment in a 500-μm mesh brass sieve. The nymphs were washed into an enamelled tray which held a fine mesh sieve and aerated, dechlorinated water. A Pasteur pipette (5-mm opening) was used to transfer the mayflies into 100 mL beakers of water and the contents were gently poured into the test chambers. For each sediment, three laboratory replicates with ten nymphs per jar, were run for a period of 21 days. Animals were not fed during the length of the test.

At the end of the test, the contents of each test chamber were emptied and rinsed in a sieve bucket. Surviving animals were counted and transferred to 150 mL beakers holding 100 mL dechlorinated water. The nymphs were immobilized with Alka-Seltzer®, blotted dry and individuals weighed to the nearest 0.01 mg, placed in vials and stored in a freezer.

Chironomus tentans Lethality and Growth Assay

Each toxicity test used 10-12 day old, cultured chironomid larvae weighing an average wet weight less than 1 mg. The OMOEE continuously cultures *C. tentans* larvae from egg to adult following standard methods (Bedard *et al.*, 1992, Mosher *et al.*, 1982, Townsend *et al.*, 1981). Egg masses were acquired from Dr. J. Giesy at Michigan State University, Lansing, Michigan and have been cultured for several generations in the MOEE laboratory.

Initially, the midges were reared in enamelled trays for a period of 10 to 12 days and then maintained in a 21 L aquarium containing 1.6 L of silica sand. The cultures were held at ambient room temperature with continuous aeration and under a 16:8 hour, light:dark photoperiod. The larvae were provided a vegetable diet *ad libitum*.

Second instar larvae were directly transferred from the enamelled rearing pans into the test chamber using the 5-mm opening of a Pasteur pipette. A total of 15 animals were added per chamber to each of the three replicates. Animals were fed a daily diet consisting of 30 mg of Cerophyll®:Tetra Conditioning Vegetable® (3:2, w:w).

After 10 days, the contents of the test chambers were emptied and washed in a sieve bucket. Surviving animals were sorted, removed and placed into 150 mL beakers holding 100 mL dechlorinated water and 15 mL silica sand. The larvae were counted, blotted dry and individuals weighed to the nearest 0.01 mg.

Pimephales promelas Lethality and Bioaccumulation Assay

The test used cultured, juvenile fathead minnows that weighed 350 mg $\pm$ 13 (s.e.) (n=40)

(wet weight). In addition, the jars holding sediment from station 0+630W were re-tested after being held under constant aeration for a total of ten days. The starting wet weight for the fathead minnows used in the re-run was 365 mg ± 96 (s.e.) (n=20). The minnows were cultured at the OMOEE laboratory and followed techniques which for the most part are US EPA procedures (USEPA, 1987) with minor revisions (Bedard *et al.*, 1992).

Cultures were maintained at 20°C in a flow-through dechlorinated water system and under a 16:8 hour, light:dark photoperiod. Breeders were kept in 60 L glass aquarium and eggs are laid on spawning tiles. The tiles were incubated in a 25°C water-bath and the developing larvae were transferred to 400 L fibreglass holding tanks. Larval fish were fed 48-hour old live brine shrimp while juveniles and breeders were provided frozen brine shrimp. Each size class was fed *ad libitum*.

Each test chamber received 10 juvenile minnows for each of the three replicates. The minnows were sorted into 250 mL glass beakers in groups of five. The contents of the beakers were emptied into a small net and the minnows released into the test chamber.

The minnows were exposed for 21 days and fed a daily diet of Tetra Conditioning Vegetable® in an amount equivalent to 1% of the average starting wet weight. After 21 days, the surviving fathead minnows were pooled from each replicate, counted, immobilized with Alka-Seltzer®, rinsed with distilled water, placed into 30 mL glass vials and frozen pending chemical analysis.

The whole body tissue samples were measured for percent lipid, 14 chlorinated organic compounds and 14 pesticides on single samples for stations 0+30 and 0+750, and duplicate samples for pre-exposed minnows, control (Honey Harbour) and station 0+244. The remaining animals were submitted for dioxins and furans either on single (station 0+30, 0 +750) or duplicate samples (station 21-S, FP-3). Insufficient biomass was obtained for station 0+630W and tissue analysis could not be completed.

Reference Toxicant Testing

A water-only reference toxicity ($CuSO_4$) test was conducted with *H. limbata* and *C. tentans* for 48-hours and LC50s were calculated for each study. The static tests consisted of four test concentrations and a control. The nominal copper concentrations were 0.05, 0.25, 0.5, 1 and 3 mg/L. Ten mayfly nymphs or midge larvae were placed into each of four replicate 250 mL beakers. To help reduce stress, five glass tubes were placed into the mayfly test beakers and a fine layer of silica sand was added to the midge test containers. Mortality was monitored every 24 hours and water quality parameters were taken at 0 and 48 hours. The mayfly test used 4 month old laboratory reared mayfly nymphs with an average wet weight of 4.62 mg ± 0.43 (s.e.). The midge larvae were 10-12 day post-hatch with an average wet weight < 1 mg.

Bioassay Schedule for Spring 1996 Sediment Samples

Test Organism	Species	Starting Date ('96)	Completion Date ('96)	Test Duration
Mayfly	*Hexagenia limbata*	Tue. June 18	Tue. July 9	21 days
Chironomid	*Chironomus tentans*	Tue. June 4	Fri. June 14	10 days
Minnow	*Pimephales promelas*	Fri. May 31	Fri. June 21	21 days
Minnow	*Pimephales promelas*	Stn 0+630W (rerun) Mon. June 10	Thur. June 20	10 days

2.4 Statistical Methods

Statistical analyses were performed using the SAS® software package (SAS, 1985). Comparisons were made among the test and control sediments using One-Way Analysis of Variance (ANOVA) and Tukey's studentized range test (HSD) and planned comparisons (Steel and Torrie, 1960). Dunnett's one-tailed *t*-test was used solely to compare mortality between the control and test sediments and the associated minimum significant difference (MSD) was described as a measure of test sensitivity. Analysis was made on arc-sine transformed mortality data. Homogeneity of variance across groups was tested using Bartlett's test. Coefficients of variation (C.V. %) were calculated for each endpoint as a measure of test precision. Spearman rank correlation analysis was used to investigate the correlation among the different biological endpoints for each species and sediment characteristics. LC50's (including the associated 95% confidence limits) were calculated using software developed by Stephan (1977) and were derived by probit analysis.

3. RESULTS

3.1 Sediment Sampling

With the exception of DDT and metabolites DDD and DDE, and a number of dioxin and furan compounds, concentrations of organic compounds in sediment were below detection limits. These include PCBs, other organochlorine pesticides, chlorophenols and chlorobenzenes. These were briefly discussed in Jaagumagi & Townsend (1996) and are not dealt with in this report. Results for the 1995 and 1996 sediment chemical analyses for the above listed parameters are presented in Appendix B.

3.1.1 Stream Sediments

DDT and Metabolites

Results for the sediment analysis for DDT compounds for 1995 and 1996 samples are presented in Table 4.

Sediment concentrations at stations 1 and 0+30 can be considered as background levels for this area. Typically, the levels of DDT and DDD were below detections limits, while DDE was present at only trace levels.

At all sampling sites adjacent to the Uniroyal site, the relative distribution of DDT and metabolites shows that most of the contamination is in the form of DDT (Figure 7). In 1995, station 0+244 (west), located on the upstream side of the weir (i.e., in the impoundment area - also referred to as the dam area) along the west side, yielded high sediment concentrations of DDT (2800 ppb). Levels of DDT and DDD both exceeded the respective Severe Effect Levels of the PSQGs (Severe Effect Levels are: 71 ug/g organic carbon for DDT; 6 ug/g organic carbon for DDD and; 19 ug/g organic carbon for DDE). Severe Effect Levels for organic compounds are calculated on the basis of the actual organic carbon content of the sediment as measured by Total Organic Carbon or TOC, and these are, as a result, site-specific guidelines. The 1996 results yielded much lower levels, at least in the surface sediment, where only trace levels were detected. Concentrations were relatively higher in the subsurface layer, suggesting that DDT has accumulated in the impoundment in the past.

Levels at station 0+240E, near the east side of the impoundment, just above the weir, were below detection limits with the exception of DDE, which was detectable only at trace levels.

In 1995, high levels of DDT (4,280 ppb) were found at station 0+270 (west) along the west channel below the impoundment. DDT, DDD and DDE concentrations exceeded the Severe Effect Levels of the PSQGs. However, at the downstream end of this channel (0+345 (west)) concentrations were much lower.

Much higher levels were found at station 0+360 (east- 1996), which was located in a large backeddy pool immediately upstream of the bridge/culvert. While surface concentrations were low, subsurface levels of DDT were 12,300 ppb (op+pp-DDT). Based on the range of TOC values at adjacent areas, these are likely in excess of the Severe Effect Level guidelines. However, this cannot be determined until TOC results are available. These results will be included in the final report.

Below the culvert, down to the confluence of

Shirt Factory Creek, relatively low levels of DDT compounds were detected. Levels along the west side ranged up to 315 ppb, while levels along the east side at station 0+450 were 55 ppb total DDT. Concentrations in Shirt Factory Creek were below detection limits above the Uniroyal plant, and ranged up to 360 ppb below.

Levels in sediment remained in the range of 200 ppb at stations 0+464 and 0+565 along the west side, and ranged up to 85 ppb at station 0+590 and 0+600, along the east side. At both 0+494 and 0+590 (west side), levels of metabolites, especially DDD were similar to, or higher than levels of DDT.

Concentrations of DDT in sediments along the west channel increased to a high at station 0+630W (identified as station 0+609 in 1995, but renamed to reflect actual distance). Concentrations ranged between 1250 ppb total DDT for the October 1995 sample, to 2800 ppb for the May 1996 sample and exceeded the Severe Effect Level guidelines for both DDT and DDD. Concentrations of metabolites were typically less than half the DDT levels and, in the 1996 samples, were much less than in 1995 samples.

Concentrations in core samples taken at 0+710 (west) were generally low and decreased with depth (i.e., below 10 cm). Similarly, while levels in the top 10 cm of the core samples at station 0+732 (west) were much higher in both years, the 1995 data suggests there is some stratification, with the 5-10 cm section having the highest concentration (up to 2960 ppb vs. 330ppb in the 0-5 cm section). The 20-30 cm section yielded only trace levels of DDT compounds.

Along the east side, down to the confluence of the main and west channels at station 0+750, only trace levels of DDT compounds were detected in sediments.

The other large backeddy/quiescent water area downstream was located at station 0+750. Levels here ranged up to a high of 2,140 ppb in the top 7 cm in 1996, while subsurface levels were much lower. In 1995, surficial sediment concentrations ranged between 200 and 400 ppb for total DDT, and indicate that levels in this area can be quite variable.

Concentrations downstream of 0+750, at station 0+785 (centre of channel) also yielded elevated levels of DDT in June 1995 samples, but levels were much lower in the October 1995 samples.

Sediments at station 0+800 (east side), located along the east side, had only trace levels of DDT and relatively low levels of metabolites.

Station 20, located just downstream of the Uniroyal property, had the elevated levels of sediment DDT in surficial layer (0-15 cm), while subsurface layer were approximately one-third the surface layers. Downstream stations showed a gradual reduction in levels of DDT and metabolites to 280 ppb at station 21, 385 ppb at station 22 and 75 ppb at station 23. The levels of metabolites remained relatively consistent at these stations.

Dioxins and furans

Results of the sediment dioxin and furan analysis are presented in Table 5 for totals for each congener group, and Table 6 for specific 2,3,7,8-substituted isomers. Distribution of 2,3,7,8-T_4CDD in surficial sediments is shown on Figure 8.

Sediment concentrations at Stations 1 and 0+30, both of which are upstream of the Uniroyal site, can be considered as background levels. Low concentrations of most congener groups were detected in these sediments, though 2,3,7,8-T_4CDD was not detected (Table 6). There was a slight increase in T_4CDD concentrations at station 0+120, at the upstream end of the impoundment, but this did not translate into an increase in 2,3,7,8-T_4CDD concentrations, which were still below detection limits.

Sediment concentrations in the impoundment area yielded low levels of most congener groups at the western end (station 0+244) accompanied by detectable levels of 2,3,7,8-T_4CDD. Levels at the eastern end (station 0+240E), just behind the impoundment structure were below detection limits in both the surface and deeper sections of the core.

Downstream of the impoundment there was a slight increase at station 0+270, along the west side channel, but levels of 2,3,7,8-T_4CDD were only slightly above the detection limit. There was however, a substantial increase noted in OCDD concentrations. Concentrations in the main channel, and along the east side were generally much lower,

with 2,3,7,8-T_4CDD not detected in these sediments. OCDD concentrations were also low and were at or below upstream levels

A significant increase occurred at station 0+360 (as noted previously, this was a depositional area upstream of the bridge and culvert). Concentrations of 2,3,7,8-T_4CDD increased to 21-23 ppt, with little difference between surface (0-10 cm) and subsurface (10-20 cm) sediment layers (Table 6; Figure 9). Concentrations of OCDD were also higher at this location.

While a concentration of 2,3,7,8-T_4CDD of up to 55 ppt was detected in sediment at station 0+397 in 1995, re-sampling of this location found levels of 22 ppt. This station was located in a very small embayment adjacent to a riffle area, that had accumulated a layer of fine-grained sediments over gravel and sand. The depth of fine sediments was approximately 5 cm, and core samples could not be obtained. Samples from the opposite bank at this location (0+406), sampled in 1995, yielded sediment concentrations of 21 ppt 2,3,7,8-T_4CDD which was similar to levels at 0+397 in 1996.

Concentrations of 2,3,7,8-T_4CDD in Shirt Factory Creek were below detection limits for station 0+468, located just upstream of the Uniroyal site. Levels downstream at station 0+456 were 5 ppt., while at station 0+494, below the confluence of Shirt Factory Creek, a concentration of 17 ppt was found in 1995.

The east bank of the creek, from opposite Shirt Factory Creek down to the confluence of the main and west channels at station 0+750 (included station 0+450, 0+590 and 0+600, 0+630E, 0+720E, and 0+738), generally had levels of 2,3,7,8-T_4CDD in the 10-20 ppt range. The exception was station 0+590, located in an embayment, where levels up to 23 ppt were found in 1995.

Sediment concentrations of 2,3,7,8-T_4CDD along the west bank down to the head of the west channel at approximately the 565 m distance, were also in the range of 10-20 ppt. Levels increased with distance down the west channel. Concentration at 0+630W (previously identified as 0+609) were in the range of 13-27 ppt, while at station 0+710 concentration increased to 71 ppt in the top 10 cm. Concentrations remained high in surface sediments at station 0+732 (54 ppt in 1996) and at station 0+750 (81 ppt in the 0-7 cm section in 1996). At all three stations, levels in the deeper sections of the cores were higher. Station 0+710 showed an increase from 71 ppt in the 0-10 cm section to a high of 290 ppt in the 20-30 cm section. Below this level, concentrations appeared to drop back to 24 ppt. However, this is based on a single core sample, rather than a composite, since only one of the three replicate cores retrieved more than a 30 cm length of sediments.

Levels below the confluence (0+785) were again in the 13-23 ppt range, similar to areas along the west side above the west channel.

Downstream of the Uniroyal property, levels dropped to below 10 ppt for 2,3,7,8-T_4CDD, with the exception of the 15-30 cm section at station 20 where levels were 25 ppt. Concentrations of 2,3,7,8-T_4CDD of between 5 and 10 ppt persisted downstream to station 23.

Calculation of total TEQ for all sampling sites show that 2,3,7,8-T_4CDD accounts for most of the potential toxicity at those stations on the Uniroyal property, and downstream.

3.1.2 Stream Bank Sediments/Soils

DDT and Metabolites

Results of the stream bank core sampling for DDT compounds are presented in Table 7.

Elevated sediment concentrations of DDT were found in bank soils/sediments at station 0+310 within the top 10 cm (Figure 10). Trace levels of DDT were found in the 10-24 cm section, though concentrations of DDE (Figure 11) were higher in this section.

In contrast, levels in bank soils at station 127-S were significantly higher, with concentrations of total DDT of 3090 ppb in the 0-10 cm section and 17,800 ppb in the 10-20 cm section (Figure 10). These were the highest levels recorded during this study. DDD levels showed a similar increase with depth (Figure 12), though concentrations were lower than for DDT.

Further downstream, along the east side, station 0+397 yielded a low concentration of DDE, trace levels of DDD and no detectable levels of DDT. A

similar pattern was observed at station 0+450, also along the east side. Both showed a slight increase in DDD and DDE with depth, though DDD was found at only trace levels down to 30 cm.

Concentrations of all DDT compounds were low, and present at only trace levels at station 0+590, located along the east side.

On the west side, at station 0+565, bank samples also yielded low levels of DDT compounds (180 ppb op+pp-DDT), though levels of DDT were generally higher than either of the metabolites.

Station 0+630W is also considered in this section, since during the various sampling periods, this area has been both exposed bank and submerged. As noted earlier, high levels of DDT have been found in surface sediments in this area. Since much of this area is sand underlaid by gravel, cores could not be obtained in this area.

Station 0+800 was located along the east bank below the OW151-2 monitoring well. Elevated levels of some solvents have been identified in groundwater samples, and this area was included to determine whether persistent organic compounds were also present. While DDT (total DDT) concentrations were relatively low, and showed only a slight increase with depth, the top section (0-12 cm) yielded a high level of DDD (780 ppb).

Dioxins and furans

Levels of dioxins and furans were relatively low at both station 0+310 and 127-S (Table 8; Figure 13). A slight increase with depth was apparent at station 127-s where levels of 2,3,7,8-T_4CDD increased from 1.8 to 4.7 ppt (Table 9). However, these levels are relatively low.

A more significant increase was noted at stations 0+397 and 0+450, both of which were located along the east bank. Concentrations in the surface (0-10 cm) at both ranged from 19-24 ppt. Levels decreased in the 10-20 cm range at both and increased again in the 20-30 cm section at station 0+397 (a corresponding section could not be obtained at station 0+450). At both locations, 2,3,7,8-T_4CDD accounted for over 75% of total TEQ.

Concentration of 2,3,7,8-T_4CDD at station 0+590 were in the 10 ppt range and showed no real change with depth (ranged from 8.7 ppt in 0-10 cm section to 11 ppt in 10-20 cm.)

In the primary seep area, located along the upper section of the west channel, a concentration of 13 ppt was obtained in the surface sediment at station 0+630w in June 1995 while in the fall this location yielded a levels of 26 ppt. In the 1996 samples sediment concentrations, at 27 ppt, were similar to the levels in the fall of 1995.

Relatively low levels of 7.7 and 4.8 ppt were found in sediment at station 0+800. Levels decreased with depth in sediment.

3.2 Floodplain Sampling

3.2.1 Sediments and Soils

DDT and Metabolites

Results of the floodplain sampling are presented in Table 10. Figure 5 shows the location of sampling sites. All areas were on the creek floodplain and, with the exception of station FP-8, were in depressions that contained standing water at the time of sampling. Stations upstream (FP-C1 and FP-C2), as well as stations immediately downstream of the Uniroyal site (FP-1 and FP-2) were close to the creek, in exposed bank areas. In most of this area, no true floodplain exists due to the high creek banks. Downstream of these areas, numerous ponds were located on the floodplain at various distances from the creek. Most appeared to be old river meanders that had been cut off and begun to fill in with soil/sediment. A few, such as FP-7 appeared to be permanent ponds with attached vegetation. However, most were shallow and appeared to be temporary ponds that likely dry up during the summer months. Core sampling was not possible in a number of these ponds due to the shallow depth of sediment. Coarse river gravels and cobble underlaid most of the downstream areas of the floodplain.

The locations immediately below the Uniroyal site (i.e., stations FP-1 and FP-2) show much higher levels of DDT in surficial sediments and generally low levels deeper down (Table 10; Figure 14). The

absence of a broad floodplain at or close to the high water mark required sampling of areas on the river plain in areas of the channel. Concentrations ranged up to 190 ppb at FP-1 and FP-2. DDD and DDE typically were less than 60ppb. Concentrations were generally much higher in the top 12 cm for DDT. DDD levels were either the same or higher in the deeper layers.

Levels decreased downstream at stations FP-3 and FP-4. At station FP-3, only DDD and DDE were present in the deeper layers (12-24 cm). Soil sampling results indicate that levels were higher in adjacent soil than in pond sediments. DDT (op+pp-DDT) concentrations in soils at station FP-3 were 215 ppb and only 45 ppb in pond sediments. DDT levels in soils were substantially higher in the deeper layers and ranged up to 920 ppb. Levels of DDT in the deeper sediment layers were below detection limits.

DDT levels increased at FP-5, as did levels of DDD and DDE, to 510, 400 and 150 ppb respectively. The DDT and DDD levels were the highest recorded in any of the ponds.

Levels of DDT at station FP-6 were 240 ppb and decreased again to trace levels at station FP-7. However, surficial concentrations rose to 105-115 ppb at stations FP-8 and FP-9, while subsurface levels were higher (up to 220 ppb at station FP-8). DDD and DDE levels were relatively higher in the subsurface layers.

DDT levels climbed to 440 at station FP-10, which was just upstream of the Grand River. Only trace levels of DDD and DDE were found at this station.

Dioxins and Furans

Results of dioxin and furan analysis of floodplain sediments and soils are presented in Tables 11 and 12.

2,3,7,8-T_4CDD was not detected in floodplain sediments above the Uniroyal site. Downstream of the Uniroyal site, 2,3,78-TCDD was detected at all sampling locations, though the distribution did not reflect any longitudinal zonation (Figure 15). Stations FP-1, FP-2, FP-4, FP-7 and FP-10 all had surficial concentrations in the 10-15 ppt range, while the other stations were typically higher. The highest concentration, 63 ppt of 2,3,7,8-T_4CDD was found at FP-5, which was a stagnant pond located near the creek in a wooded area. While all of these stations were relatively close to the creek, station FP-5 in particular, was close to creek elevation.

Most stations showed only a slight increase with depth except for station FP-3, where levels in subsurface (12-24 cm) sediments were approximately 2.8 times higher. Station FP-3 in 1995, yielded a sediment concentration over a 10 cm depth of 110 ppt 2,3,7,8-T_4CDD, while in 1996, concentrations in the top 10 cm, at 23 ppt, were much lower. Soil samples collected from areas of the bank between the creek and the pond, had slightly lower concentrations of 2,3,7,8-T_4CDD in both surface and subsurface layers.

At nearly all stations, 2,3,7,8-T_4CDD comprised over 75% of the total TEQ.

3.2.2 Water Column

Dioxins and Furans

Results of the water column testing found generally non-detectable levels of dioxins and furans in the water. The results of the water analysis are presented in Table 13. However, the levels of dioxins and furans, particularly levels of TCDD, increased substantially in both ponds after the sediment was disturbed. Levels of 2,3,7,8-T_4CDD were still below detection limits and it would suggest that other, less toxic isomers were primarily present in the resuspended material. Total TEQs were very low in the undisturbed water samples, as well as the disturbed water sample from station FP-7, and were well below the Canadian Water Quality Guidelines (CWQGs) of 0.38 pg/L (Provincial Water Quality Guidelines are currently not available for these compounds). The disturbed water sample from station FP-3 exceeded these guidelines (Table 13), though levels were well below the CWQG livestock watering guideline of 39 pg/L.

3.3 Benthic Community Analysis

Benthic community structure analysis was used as one of the tests to determine the impact of

contaminants in sediments on biota.

Benthic communities (i.e., those organisms that live on and in, and often ingest, sediments) have often been used as a measure of the effects of contaminants. The method makes use of the different responses to contaminants among different groups of organisms. The analysis considers those organisms that are present, as well as considering those that would be expected to be present, but for some reason are not. The method is based upon the classical ecological definition of a natural, undisturbed community as one that consists of a few species which are commonly distributed and present in greater densities, and a larger number that are sparsely distributed and relatively rare. In a natural state, such a community exists as a balance between these two groups. Under environmental stresses, the natural balancing mechanisms (e.g., availability of food, predation, competition for resources) are disrupted and an unnatural, stress-defined community develops. These are usually characterized by the absence of the more intolerant or sensitive groups and the overwhelming presence of a few groups that are tolerant of the new conditions. Under conditions of chemical contamination, for example, both diversity (the range of different types of organisms present) and the density (the actual numbers) are reduced, as only those tolerant of the contaminant(s) are able to survive.

Where the toxic effects of contaminants are high (i.e., highly toxic compounds, high concentrations or high bioavailability of the contaminant) the effect on the benthic community is usually severe: elimination of most of the benthic taxa, and the presence, in very low numbers, of those few that are tolerant. Conversely, where contaminant concentrations are low, or there is low bioavailability of the substance, the effect on the benthic community may be minor, such as a slight reduction in overall density. Where low concentrations of contaminants are present, those organisms present are often indicative of long-term chronic effects on organisms, since the community that exists is the result of the effects of the contaminant(s) acting over a number of generations.

In interpreting benthic community information a number of natural factors need to be considered, since the nature of the community depends not only on the presence of contaminants, but also natural factors such as substrate type, water temperature and flow regime. Most benthic organisms have specific habitat requirements. Some, for example, prefer soft fine-grained sediments in quiescent waters, while other species may prefer hard substrates in flowing water. These preferences are usually based upon the feeding requirements of the organisms. Those that feed by ingesting sediments (i.e., that feed upon the organic fraction) will usually require fine-grained material with some organic matter. For example, both chironomids (midge larvae) and oligochaetes (aquatic relatives of earthworms) ingest sediments to extract organic matter and are often the most common components of benthic communities in quiescent water such as lakes and ponds.

Differences are also apparent in temperature requirements, and generally, cold waters support different types of organisms than warm waters.

Therefore, the analysis must also consider habitat characteristics in conjunction with presence-absence of taxa.

Benthic community structure analysis results are presented in Tables 14 and 15.

Since, as noted above, benthic organisms often have specific habitat requirements, sampling was restricted to depositional areas. Species composition between riffle areas and depositional areas is significantly different and mixing the two would not permit useful comparisons among the sampling stations. A sampling strategy focusing on one habitat type, however, would permit comparison of benthic communities at different locations along the creek, in areas of similar substrate type, and thus would be able to determine differences in community structure that were not related to habitat.

At nearly all locations, oligochaetes and chironomids formed the majority of the benthic fauna (distribution of major taxa for all stations is shown on Figure 16). Since sampling was conducted in quiescent areas where fine sediments would accumulate, these types of habitats would exclude many benthic organisms. Those species specifically adapted to such areas include a large number of species of the oligochaetes and chironomids.

The upstream stations (1 and 0+30) indicate that the stream fauna in depositional areas is

primarily composed of oligochaete and chironomid species. The oligochaete fauna was composed of species typical of organically enriched areas, with *Limnodrilus hoffmeisteri* the most numerous species at station 1. Density of both chironomids (3,500/m^2) and oligochaetes (22,000/m^2) at this station was high. The benthic community at station 0+30 was characterized by greater species diversity, and also included a number of naidid species as well. In comparison with station 1, density of both chironomids and oligochaetes was much lower. At both locations, the chironomid fauna was also limited to a small number of taxa (mainly *Chironomus* and *Cryptochironomus*) both of which were indicative of highly organic conditions and are typically found where organic matter has accumulated. Much of the watershed above the Uniroyal site is under agricultural usage (as is most of the downstream as well), and would be expected to receive agricultural runoff.

The two stations in the impoundment area (0+240E and 0+244) showed little difference in benthic community composition when compared to station 0+30. The species present were similar, as was the respective density of the main taxa. While density was slightly lower at station 0+240E, the differences were not statistically different.

Station 0+270 was located in the west channel below the impoundment. Sediment concentrations of DDT in 1995 (benthic samples were taken concurrently with sediment samples) at this site reached 4,280 ppb, which was above the Severe Effect Level. While oligochaete density was high in all replicates (comparable to station 1), and species composition was similar (fauna was dominated by *Limnodrilus hoffmeisteri*), the chironomid fauna was conspicuously absent in two of the replicates. However, density was high in the one replicate and the population included orthoclad species (*Cricotopus* and *Nanocladius*) that are commonly indicative of flowing water. The substrate type in this area was different due to the flow in this channel, with fine-grained silty material present only in pockets along the side of the channel. Due to the small size of the deposit, two of the three replicates were collected in silty-sand, while the third was at the edge of this deposit in a more erosional area characterized by mainly sand and gravel.

Diversity of benthic groups increases at the three stations downstream of the west channel below the impoundment. Chironomid populations are present at locations 0+330C, 0+320 and 0+330W, though density at 0+320, on the east side, was significantly lower than the other two stations.

Benthic communities at stations 0+345, 0+360 and 0+397 were similar to upstream stations and controls. Diversity of taxa was high at both locations, though both the oligochaete and chironomid fauna were still represented primarily by warm-water species indicative of high organic matter.

Both chironomid and oligochaete density increased substantially at stations 0+406, located on the west side above Shirt Factory Creek, and 0+494, located below the creek confluence. Organic matter accumulation appears to be particularly high at these locations as indicated by these increases. This increase persisted downstream as far as station 0+565. The significant increase at station 0+494 in particular suggests inputs of organic matter from Shirt Factory Creek.

In contrast, stations 0+450 and 0+600 along the east side had relatively low density of these groups, but overall diversity was much higher.

Station 0+630E was located downstream near the east side of the creek. Oligochaetes were conspicuously absent and the chironomid community was also significantly reduced. The burrowing species that have been particularly abundant at upstream locations were absent. Only three species were present, and these in very low numbers. Of the three, two, *Polypedilum* and *Cricotopus/Orthocladius* are feeders on surface detritus. While contaminant concentrations in sediments were relatively low in comparison with other sampling sites, sediments were characterized as black, oily sand and silt with a strong chemical odour (Table 2.1).

Along the west channel the benthic community at station 0+732, in both 1995 and 1996, had relatively high densities of oligochaete species. While density in 1995 was approximately 3 times higher, species composition was similar in both years. Chironomids, however, showed a reduction in the number of species from 1995 to 1996. The community in 1995 included sediment burrowing

species such as *Chironomus* and *Cryptochironomus*, while in 1996 these were absent and only predators (*Procladius*) and surface feeders (*Polypedilum*) were present in low numbers.

Station 0+738, located along the east side was more typical of upstream locations, and diversity was relatively high at this location.

Station 0+750 was also sampled in both 1995 and 1996. Oligochaete community composition was similar in both years, though density was generally lower in 1996 samples. A similar trend in reduction of density was observed in the chironomid fauna, as well as a similar trend towards species with more epibenthic habitat requirements.

Station 0+785 was located in the main channel below the west channel (near the STP outfall) adjacent to a sand bar. The high amount of organic detritus (decaying plant matter) noted in these sediments is reflected in the benthic community, which is generally more diverse, and in particular, the chironomid community, which is represented by detrital feeding species such as *Cricotopus*, *Paratanytarsus* and *Rheotanytarsus*. However, the burrowing species are again reduced. In contrast, the oligochaetes (nearly all of which are burrowing species), showed little difference in species composition with upstream stations.

Station 0+800 was located on the east side below the STP outfall beside a gravel bar. This station differed in physical characteristics from most other s in the high sand and gravel content. Since sand and gravel hold little nutritive value, these areas are typically unable to support diverse benthic communities. The small amount of detritus and fine particulate matter that does get trapped in these sediments means that density is often severely reduced. This appears to be the case with the oligochaete fauna. While most of the species common in upstream areas are present, they are present at much reduced numbers. The distribution of the chironomid community follows a similar pattern.

Stations downstream of the Uniroyal site were all relatively similar in species composition of the oligochaete fauna, though there was considerable variation in density. The chironomids showed more variation in species composition, with station 21S differing from the other creek stations. The substrate in this location was mainly sand with only a minor amount of silt. As expected, the burrowing species such as *Chironomus* were absent and instead detrital feeders predominated.

Station 21p was a special case. This was a pond on the floodplain, and the benthic fauna differed considerably from the creek stations. The only chironomid species present was *Paratendipes*, while the largest percentage of the fauna was comprised of ceratopogonids, both of which are commonly found in temporary pools. The indication is that this is a temporary pool, that dries up during most summers.

3.4 Benthic Tissue Residues

Dioxins and Furans

Results of the benthic organism tissue residue analysis are presented in Table 16.

Tissue residues of 2,3,7,8-T_4CDD at station 0+30 were below detection limits and there was no detectable TEQ.

Tissue residues at station 0+565 were 2.5 ppt wet weight. Converted to dry weight, assuming an organisms water content of 84% (Persaud et al 1987), gives a dry weight value of 16 ppt, which can be compared to sediment concentrations. The dry weight value of 16 ppt is slightly higher than the sediment concentration at this site of 14 ppt (based on 1995 results - stream sediments were not re-sampled in 1996).

Tissue residue at station 0+750 was 9.7 ppt wet weight of 2,3,7,8-T_4CDD or 61 ppt dry weight. The mean sediment concentration at this site over the three sampling periods is 60 ppt.

3.5 Laboratory Sediment Bioassay Testing

Whole-sediment toxicity tests were conducted for five field locations using the mayfly nymph, *Hexagenia limbata* (21-day exposure, survival, growth and avoidance behaviour), the midge larvae, *Chironomus tentans* (10-day exposure, survival and growth) and the juvenile fathead minnow, *Pimephales*

promelas (21-day exposure, survival and chemical bioaccumulation). The battery of sediment toxicity tests provides a number of endpoints using organisms representing different trophic levels in order to measure differences in sediment quality. The laboratory toxicity tests provide a cost-effective technique for determining if sediment-associated contaminants are harmful to benthic organisms or are being released into the water-column. In conjunction with appropriate control sediments, spatial differences in sediment quality, the relative availability of contaminants and their potential impacts can be ascertained. Relationships between sediment concentrations of a number of contaminants and observed biological effects were examined, along with intercomparisons in sensitivity of different test organisms and endpoints.

Water Quality Test Parameters

Conductivity, pH, total ammonia, un-ionized ammonia and dissolved oxygen parameters were periodically measured in the overlying water for each test species in each of the three studies. The results are summarized in Table 17. Values are reported as mean, $\pm$ standard deviation. Similar pH and conductivity water quality measurements were recorded among the test sites, regardless of test species or study. For the reference control and test sites, pH averaged from 8.0 to 8.3 and conductivity from 501 to 556 umho/cm. Dissolved oxygen within the test jars remained above acceptable levels (>4 mg/l) throughout the test (OMOEE, 1994). Test temperature was at or near 20°C for each bioassay.

Total ammonia and converted un-ionized ammonia readings exhibited the greatest variability. The reference and all test sediment exposures had average un-ionized ammonia concentrations above the PWQO of 0.02 mgNH_3/L. Station 0+630W and 0+750 sediments consistently resulted in concentrations in the overlying water that were twice background levels, as reported for station 0+30 (Ave: 0.06 mg/L $\pm$ 0.03), in all three toxicity tests. The highest readings occurred for station 0+750, where concentrations were 20-fold, 6-fold and 4-fold above reference conditions in the midge, minnow and mayfly tests, respectively. Values ranged between 0.24 and 0.81 mgNH_3/L. Markedly higher ammonia concentrations were also reported for station 0+630W exposures (Range: 0.18 to 1.58 mgNH_3/L). The remaining test sediments generally had comparable average un-ionized ammonia concentrations (Range: 0.03 - 0.09 mg/L) to those attained in the reference sediment.

The data indicates that a certain amount of the un-ionized ammonia entering the water column is attributable to background conditions and common to the study area. Differences in un-ionized ammonia concentrations that exist at stations 0+630W and 0+750 cannot be solely attributed to the test organisms, given the consistency in readings among each toxicity test. Instead it is more likely that the elevated un-ionized ammonia concentrations is a result of ammonia associated with the sediment diffusing into the overlying water column. Groundwater monitoring studies have noted levels of total ammonia in the groundwater at locations in the vicinity of stations 0+630W and 0+750, in the range of 49 to 144 mgN/L (CRA, 1996). In comparison, the same survey reported a concentration of 1 mgN/L at a site upstream, near station 0+244.

Sediment Characterization

The following sections summarize the sediment physical and chemical parameters to aid in the interpretation of the biological toxicity results. The data applies to the sediment samples prepared for the laboratory toxicity tests and results may differ from those reported for the field sediment samples. Any differences are likely a reflection of in-situ heterogeneity and/or sampling technique employed in the collection of the sediment.

Sediments were characterized for % sand (2mm-62μm), % silt (62-3.7μm), % clay (3.7-0.1μm), % loss on ignition (%LOI), total organic carbon (TOC), total phosphorus (TP) and total Kjeldahl nitrogen (TKN) (Table 18). Both reference and negative control sediments were characterized as being fine-textured sediments, comprised mainly of silt-sized particles (60 - 70%) and slight amounts of organic matter (22 to 24 mg/g TOC). In terms of particle size composition, the control sediments adequately represent all the of the test sediments, with the exception of station 0+630W. Laboratory observations made during sieving noted station 0+630W sediment to be a hard-packed sandy substrate. Station FP-3 sediment, collected in the floodplain, was the most organically-enriched and had

the highest amount of organic material (40 mg/g TOC) and TKN (3 mg/g), which corresponds with increased inputs from surrounding agricultural lands. Leaf litter was found in the sample. Total organic carbon concentrations ranged from 17 to 31 mg/g for all other test and control sediments.

Bulk sediment samples were analyzed for 11 trace metals (Table 19). Comparison of the test sediments with the reference control sediment show metal sediment concentrations to be similar and no exceedances of the PSQG-SEL were reported.

Bulk sediment concentrations for pp-DDE, op-DDT, pp-DDD, pp-DDT, g-BHC and total 2,3,7,8-T_4CDD toxicity equivalent concentrations (TEQ) for PCDDs and PCDFs are reported in Table 20. Dioxin and furan concentrations were restricted to two test samples and the reference sediment. The upstream location had a TEQ of 0.73 pg/g and a maximum TEQ of 200.19 pg/g at station 0+750. For the pesticides, either non-detectable or trace amounts were found in the negative and reference sediments, along with the floodplain sample (stn FP-3). Bulk DDT (including metabolites DDD and DDE), sediment concentrations were typically above PSQG-LEL concentrations in the remaining samples. pp-DDD surpassed the SEL concentration (corrected for OC) at stations 0+630W and 0+750, by 171-fold and 2-fold, respectively. Other compounds including 15 organochlorine pesticides and 14 chlorinated organics were not present above non-detectable concentrations in all samples.

Station 0+630W sediment was described as having a shiny, black appearance and emanated a very strong (solvent-like) chemical odour. Station 0+750 sediment shared similar features but not quite as strong a chemical odour. These attributes were also recognized in the corresponding field samples.

Mayfly (*Hexagenia limbata*) 21-day Lethality and Growth Results

The biological data for the two endpoints, mortality and growth, are summarized in Table 21. Mayfly mortality was nil for three of the test sediments (stations 0+244, FP-3, 21-S) and both control sediments. Mortality was 100% for mayfly nymphs exposed to station 0+630W sediment and differed significantly relative to the control and other test sediments (ANOVA $p<0.0001$; Dunnett's 1-tailed *t*-test $p<0.05$). Laboratory inspection of the test chambers indicated station 0+630W sediment was acutely toxic, with 90% of the animals dead by Day-7. During the first 48 hours, at least 80% of the animals showed strong avoidance of the sediment and were not actively burrowing. Average percent mortality was 46.6% $\pm$ 5 (s.d.) on Day-3 and most of the remaining survivors were found on the sediment surface. Significant lethality was also found in station 0+750 exposures (Ave: 50% mortality) and was statistically higher than mortality ($p<0.05$) in either control sediment. The first recorded death occurred on Day-16, with the majority falling on Days-20 and -21. Just prior to terminating the test, at least 36% of the surviving nymphs were located on the surface of the sediment.

Significant differences in the sublethal growth endpoint were measured among sites ($p<0.0001$) (Figure 17). This occurred for the control and station 0+750 animals, which had the lowest average individual body weight (5.8 and 6.2, wet weight). Comparison analyses indicated a similar range of growth for each of the other test sediments (33.7 to 36.9 mg) relative to the reference control weight of 36.2 mg. Growth at these locations resulted in at least a 6-fold increase in biomass relative to the average mayfly starting size. The lower mayfly growth obtained for the negative control sediment was probably due to the quality and quantity of the nutritional value associated with the sediment due to the prolonged storage of this sediment, relative to the fresh detrital material found in the reference and test sediments.

Chironomid (*Chironomus tentans*) 10-day Lethality and Growth Results

Results for chironomid growth and lethality are reported in Table 21. Sediments from stations 0+630W and 0+750 were found to be acutely toxic, with 93% and 51% mortality, respectively ($p<0.0001$). These values are significantly higher than both sets of controls (Ave: 6% mortality). The remaining test sediments resulted in a similar degree of mortality as the control exposures (Range: 2% to 13% mortality).

Chironomus growth (9.6 mg) was significantly lower for station 0+750 sediment relative to the remaining test sediments and both controls ($p < 0.0001$) (Figure 17). This represented a minimum reduction in biomass of 24% relative to the control weights of 12.7 and 15.9 mg.

Fathead Minnow (*Pimephales promelas*) 21-day Lethality Results

Juvenile fathead minnow percent mortality data is reported in Table 21 and illustrated in Figure 17. Percent mortality ranged from 0% to 3% for the negative control, reference control, 0+244, 21-S and FP-3 sediments. Slightly higher toxicity was found for station 0+750 (20% mortality) and was statistically different than all other samples, including both controls. Loss of fathead minnows commenced on Day-10 and continued throughout the rest of the test. The greatest toxicity occurred for station 0+630W (100% mortality). Death was rapid, where 46.6% $\pm$ 5 (s.d.) of the animals died within the first 24 hours. During this time period animals exhibited obvious signs of stress. Locomotor activity was slow, with fish either observed resting on their sides on top of the sediment surface or swimming sideways near the water surface. In addition, fish were easily startled by outside stimuli. By Day-2, average percent mortality was 96%. The jars holding station 0+630W sediment were allowed to aerate for another seven days and a fresh batch of animals was introduced. Death was immediate for one of the three replicate jars. In the other two replicate jars, death progressed more slowly than during the first experimental run and no animals were recovered after Day-10. By Day-2, fish were exhibiting similar signs of stress as those reported using fresh material.

Chemical Bioaccumulation in *Pimephales promelas*

The examination of organic chemical availability to aquatic organisms is valuable for assessing the potential for chemical transfer through the food web. The primary objective of this test procedure is to make general observations on whole organism tissue concentrations as they relate to overall bulk organic chemical concentrations in the sediment and differences in chemical uptake among transects. Surviving fathead minnows were submitted for chlorinated organics and/or dioxins and furans analysis, and are based on whole-body tissue concentrations (ng/g, dry weight). A dry to wet ratio of 0.16 was used to convert from a wet weight to a dry weight basis (Persaud *et al.* 1987).

The sources of organic compound accumulation to forage fish include direct contact with the sediment and uptake from the overlying water. Factors that control chemical accumulation by forage fish include those that affect chemical adsorption and desorption such as sediment organic content, particle size distribution and chemical partition coefficient, also known as the octanol-water partition coefficient, Kow (Lake *et al.*, 1990). Biotic factors affecting uptake include metabolism and lipid content (Boese *et al.*, 1995).

Results of the fathead minnow tissue analysis for dioxins and furans are presented in Table 22. At the control station, there were no detectable levels of dioxin or furans in fathead minnows. At the downstream locations, concentrations of 2,3,7,8-T_4CDD ranged from 70% of sediment levels at station 0+750 (107 ppt dry weight) to 118% of sediment levels at station FP-3 (20 ppt dry weight).

The only other compound accumulated was OCDD at station 0+750, though tissue levels were only approximately 3% of sediment concentrations, and contributed little to the total TEQ accumulated by the minnows. OCDD was not accumulated by minnows in any of the other test sediments.

Table 22b describes the DDT residues for fathead minnows and sediment at selected sites. Fish concentrations are provided on a wet weight and dry weight basis. Background DDT, DDE and DDD minnow concentrations are represented by two procedures. First, the pre-exposed minnow tissue concentrations reflect any DDT that may have been acquired through culturing practices, and second, the Honey Harbour control and the on-site reference control (stn 0+30) exposures are an indication of DDT availability at relatively unimpacted sites. In both circumstances, values were either below detection limits, or at trace amounts e.g. pp-DDE, 5 ng/g < T .

DDT uptake was examined at two creek locations. At stn 0+244 and 0+750, op-DDT and

pp-DDT tissue concentrations were at or below trace amounts. Although pp-DDD was measured in the sediment at quantifiable concentrations at both locations, it was only at the higher sediment concentration (520 ng/g; dry weight), that pp-DDD occurred above trace amounts in the fish (85 ng/g; wet weight). The fathead minnow pp-DDD dry weight tissue concentration actually equalled the concentration in the sediment at stn 0+750.

Both test sediment 21-day exposures illustrated substantial accumulation of pp-DDE, resulting in levels in fish that exceeded the sediment concentration by 9-fold to 165-fold. The ΣDDT tissue concentration (in wet weight) was fairly consistent for each batch of fish analyzed; 134 ng/g (minnow A, station 0+244), 166 ng/g (minnow B, station 0+244) and 120 ng/g (minnow A at stn 0+750). Average fish percent lipid was 0.8% ± 0.2 (s.d. n=3) for the control animals and 0.7% ± 0.2 (s.d. n=3) for the test animals.

Quality Assurance Data

Coefficient of variation was calculated for each endpoint and showed good to excellent test precision (Range: 8 % to 35% C.V.) across species and test response (Table 21). The lower the C.V., the greater the confidence in the precision or accuracy of the test results. Another useful quantitative measure of test precision is the minimum significant difference or MSD, which describes the ability to detect a significant effect in the paired response between the control versus the test sample. The MSD was determined for percent mortality and was similar among each toxicity test (MSD = 14% - 21%). The use of only three replicate test chambers per sample provided an adequate degree of efficiency in detecting small differences in lethality between the test and control exposures. Values parallel those found in the literature for *C. tentans* 10-day sediment lethality tests (Becker *et al.*, 1995; Burton *et al.*, 1996). The mortality endpoint in the *Hexagenia* and *Pimephales* toxicity tests yielded the best discriminatory power values (D.P. 30 and 35). The ability to distinguish between lethal and non-lethal sediment samples was in part due to the small variability among replicates and is a reflection of the broad range in response which varied between 0%-3% to 100% mortality. A somewhat lower D.P. of 9 was noted for midge mortality as a result of the slightly higher control mortality (2%-11%).

Overall, the test results were highly intercorrelated, with several positive relationships occurring among test endpoints and test species (Table 23). In other words, each toxicity test was capable of identifying the same group of lethal sediments (station 0+630W and 0+750) and non-lethal sediments (station 0+244, 21-S, FP-3).

The 48-hour copper LC50s (95% C.I.) for the water-only reference toxicant exposure for *H. limbata* was 0.39 (0.20 - 1.69) mg/L. This value was within the acceptable 48-h LC50 (± 2 s.d.) range of 1.40 (1.25) mg/L, according to a previous series of reference toxicant tests. Similarly, for *C. tentans*, the LC50s was 1.19 (0.58 - 4.98) mg/L, as compared to an expected 48-h LC50 (± 2 s.d.) of 1.37 (1.00) mg/L.

4. DISCUSSION

4.1 Creek Sediments

Levels of DDT and metabolites in other areas of the province where there is intensive agricultural use of the land often shows a record of historical DDT use. Typically, in these areas, levels of the metabolic products, DDD and DDE are higher than the parent product, which is relatively more unstable and will decay to DDD and DDE through the action of anaerobic bacteria. The high levels of DDT relative to the metabolic products, as indicated in the report on the 1995 investigation (Jaagumagi & Townsend 1996), are indicative of a recent source of DDT.

While DDT is susceptible to decay through microbial action (biotransformation) to DDD and DDE (Smith *et al.* 1988), the latter two products are very resistant to further decay. The presence of solvents, such as toluene, in the groundwater (Conestoga-Rovers & Associates, 1996) could act as carriers for the DDT, and could also retard the decay of DDT through inhibition of microbial activity.

As in the 1995 investigation, DDT concentrations in Canagagigue Creek sediments upstream of the Uniroyal site were below detection limits (Table 4). Only the metabolic product pp-DDE

was detected at trace levels in these sediments. These could be taken as typical of background levels of DDT compounds and would likely reflect historical use of DDT for agricultural purposes.

The higher concentrations of DDT in the impoundment area, and the differences in 1995-96 data for station 0+244, suggest that distribution of DDT compounds in impoundment sediments is uneven (Figure 18 shows the distribution of DDT as Total DDT + DDD + DDE, in creek sediments and bank sediments/soils along the creek). Since the impoundment area was dredged recently (July-August 1994), the history of deposition cannot be determined from sediment cores. However, the data suggests that pockets of higher distribution have remained after the dredging. The 1995 monitoring report (CRA 1996) noted that DDT and metabolites were detected in ground water samples at well OW94-4 (located at approximately 0+190), on the west side of the creek. Sampling conducted in 1996 yielded no detectable levels in well OW94-4 (CRA 1997) and additional monitoring would be warranted in this area. As noted earlier, both DDT and 2,4,-D were disposed of in waste pits in this area. Therefore, through erosion of contaminated soils this area could act as a source of DDT compounds, as well as dioxins and furans, to the impoundment area.

The west side of the impoundment area has been identified (CRA 1991, 1993) as the location of waste pits for the disposal of DDT and other waste products such as 2,4,-D (identified as RPW-1 in CRA 1991). Therefore, there is potential for contamination of soils in this area, in addition to the groundwater contamination detected by CRA (1996). As such, a number of transport mechanisms exist, including erosion of contaminated soils from this area.

The very low levels of DDT compounds next to the weir near the east side of the impoundment (station 240E), together with monitoring well data (CRA 1996), does not indicate the existence of a significant source on the east side. However, the history of accumulation in sediments above the impoundment is difficult to determine since the impoundment was dredged recently (1994). Sediments at this location were dredged immediately upstream of the weir, but it is unclear whether dredging was undertaken up to the weir. If not, then this could be a more accurate record of depositional history than station 0+244, which was approx. 5 m upstream of the weir, and more likely to be in an area that was dredged.

A review of the site history, conducted by CRA (CRA Pers. Comm. 1997) indicates that dredged materials removed from the impoundment in the early 1950's were placed on the northwest section of the property (Figure 27). Erosion of contaminated soils from this section may also be contributing to higher sediment concentrations of DDT at and below the impoundment.

In the section below the impoundment, concentrations along the west channel were highly variable. The 1995 study found high levels near the upstream end of this channel at station 0+270, while downstream stations indicate that little has accumulated in this section. The elevated levels at station 0+270 may be related to higher levels in the impoundment at station 0+244 in 1995. The presence of DDT compounds in groundwater monitoring wells suggests migration with groundwater. The area near OW94-4, adjacent to the impoundment, has been identified as a groundwater recharge area, with movement being down to the creek near the 127-S well. As such, the former waste pits could have, and may still be contributing contaminants to the section near 127-S. The locations of the waste pits and the relevant on-site buildings are shown on Figure 27, which is reproduced from CRA (1997b).

Station 127-S was located adjacent to a former disposal area identified on Figure 27 as P-1. According to CRA (1991) this area was used from 1942 to 1945 for the disposal of a variety of wastes. From 1945 to 1948 (CRA 1997b), DDT production on the site was between 200,000 and 300,000 lbs/yr. The wastewater from the DDT production facility (identified as building 3) discharged to a sump (building 8 sump) which in turn discharged to the P-1 area until 1945, at which time P-1 was closed. Subsequently, clarified wastewater from the sump was redirected to Shirt Factory Creek (CRA 1997b). Thus, it appears that for at least some of the time during which DDT was produced at the plant wastewaters that could have contained DDT were discharged to the P-1 area, and may account for the higher DDT concentrations in bank sediments. However, it is unclear whether P-1 would have received sump discharges for more than a short period of time since the closing of P-1 appears to coincide with the full production of DDT.

Recent information (CRA 1997b) notes that the entire creek bed on the site was deepened in the early 1950's and that removed material was placed on the west bank of the creek.

Results from both the DDT and dioxin and furan analysis suggest there has been accumulation of these compounds in sediments in the downstream end of the impoundment. Prior to dredging, this area could have been a source of contaminated sediments to downstream areas. The dredging could also have re-suspended considerable amounts of bottom sediments, which would have been washed over the weir and deposited in downstream areas.

The depth of contaminated sediments in downstream areas, such as station 0+360, suggests that loss of sediment during dredging is not the only source. Continual loss from the impoundment area before dredging seems very likely, given that very high DDT residues were found down to a depth of 24 cm at station 0+360.

Additional sources along the west side, below the weir, are suggested as well. CRA (1997b) note that while pits RPW-1 and RPW-2 were being used, overflow from the pits was directed, via a pipe, to the creek. Similarly, the close proximity of P-1 to the creek resulted in periodic inundation of this area during high flows (CRA 1997b).

DDT and metabolites were found in a water sample from monitoring well 127-S in 1995 (CRA 1996). Bank cores in this section yielded DDT in both exposed bank sediments adjacent to the 127-S well (station 0+310), as well as in bank soils immediately downstream (station 127-S). The highest concentrations of total DDT, up to 17,800 ppb, were found in the 10-20 cm section at station 127-S. Unlike the sample at station 0+310, which was in exposed bank sediments (mainly sand and silt with no vegetation cover), samples from 127-S were collected from cohesive bank soils with rooted grasses and other vegetative cover.

DDT compounds were not detected in monitoring well OW153-4 in 1996, which is located down-gradient of both well 127-S and the sediment/soil sampling locations of 0+310 and 127-s (CRA 1997). These results suggest that contaminant transport has not occurred down to this area and is supported by the sediment sampling data, which found much lower levels of DDT compounds at station 0+345.

The higher levels in the deeper sections suggests movement of DDT with groundwater. CRA (1996) has noted that groundwater movement is from the impoundment area, across the former waste pit location near well OW94-4, which has been identified as a groundwater recharge area, and down to the section of the creek near well OW127-S, where it joins the creek. It is also possible that during operation, the fluid in the pit may have been higher than the impoundment area, creating groundwater flow in that direction (J. Warbick, Pers. Comm.). Records indicate that these pits, identified as RPW-1, were used for the disposal of a variety of wastes including DDT and 2,4,-D (CRA 1991). When the pits were closed between 1968 and 1975, the area was simply backfilled with fill of unknown origin (CRA 1991).

The waste pits have likely been a source of DDT compounds, as well as dioxins, throughout their operating life. In addition to direct discharge from pits RPW-1 and RPW-2, benzene, toluene and xylene, among others, have been detected in soil samples from the waste pit area (CRA 1993), suggesting these compounds were, and may continue to be, present in the pits as well. Over time the disposed solvents could have resulted in mobilization of the persistent compounds, and their resultant migration down-gradient. Groundwater monitoring data suggests that this area continues to be a source of persistent contaminants.

The higher bank sediment concentrations in the section at OW127-S, represent potential sources of DDT through erosion, and possibly through groundwater movement to the creek. The long-term migration of DDT compounds and dioxins and furans with contaminated groundwater could result in a build-up of contaminant residues in the soils, which in turn become a source of contaminated sediment to the creek through erosional processes.

The use of the northwest section of the site as waste disposal areas in the 1940's and early 1950's indicates that process wastewater from DDT production could have resulted in accumulation of DDT in soils and sediments. As noted earlier the P-1 area was filled in, though prior to that, the area had been marshy with periodic inundation by the creek

during high flows (CRA 1997b). This could have enabled the release of DDT contaminated water or sediments to the creek.

CRA (1997b) also noted that the entire length of the creek on the Uniroyal property was deepened during the early 1950's, with dredgeate disposal on the west bank. Sediments that could have been contaminated with DDT through overflow of the RPW-1, RPW-2 and P-1 pits may have been subsequently placed on the creek banks.

Once contaminants or contaminated soil reaches the creek, the generally hard substrate, which characterizes the small west channel below the impoundment as primarily erosional, indicates there is little likelihood of deposition of sediments in this section of the stream. In particular, the downstream section of this channel is primarily erosional with few quiescent areas that would favour deposition.

The major depositional area in this section of the creek appears to be the large backeddy pool along the east side above the culverts (Station 0+360). The deeper layer at this station had the highest levels of DDT encountered in the creek (12,300 ppb). The location and configuration of this area suggests that this is an area of active fine-sediment accumulation from upstream areas. The faster flows in the upstream areas would preclude accumulation in those areas, and the material would settle in the first major quiescent area downstream. This area appears to be relatively protected from washout during high water and in fact, the presence of the culvert/bridge would serve to retard the stream flow during high water periods, enhancing the settling of particulate matter in this area.

While surficial sediment analysis (station 0+360, 0-10 cm section) suggests most of the deposition has been historical, only one sample was collected at this location. Therefore, it cannot be determined whether deposition of DDT contaminated sediments is still occurring, since the backeddy area was quite large, and deposition within this area could vary considerably.

The levels of DDT compounds in Shirt Factory Creek suggest that some has entered Canagagigue Creek from the property. Upstream of the Uniroyal site, levels of all compounds were below detection limits, while stations downstream had levels that ranged from none detected (station 0+438) to 360 ppb (0+456). Levels of metabolites were generally lower than DDT, again suggesting that historical agricultural use is not the likely source.

CRA (Pers. Comm. 1997) has indicated that overflows from the Building 8 sump, which could include DDT compounds, have in the past drained to Shirt Factory Creek and this may account for the elevated DDT levels downstream.

While low concentrations of DDT and metabolites were detected in groundwater samples at wells OW71-2 and OW141-2 in 1995 (0.019 to 0.031 ug/L) (CRA 1996) along the east side opposite Shirt Factory Creek, creek sediments below this section (0+450, 0+590 and 0+600) generally had much lower levels than stations along the west side, at and below, Shirt Factory Creek. Stations 0+590 and 0+600 were located in a large embayment on the east side below these monitoring wells and should be primary areas of deposition. Bank sediments (0+450 and 0+590) indicated low concentrations in bank materials.

Opposite this section, on the west side, levels of up to 200 ppb were found below Shirt Factory Creek as far downstream as the head of the small west channel at approximately the 565m mark. The higher levels of DDD and DDE at both east and west stations suggests more weathered material in these areas. CRA (1997b) indicates that for much of the period during which DDT was produced at the site, discharge of process wastewater was to Shirt Factory Creek via the Building 8 sump.

The west channel has been identified as the primary seep area. High concentrations of a number of volatile organic compounds, such as toluene, have been detected in groundwater monitoring wells in this section (CRA 1996). A number of waste lagoons were previously located in this section of the site, which were used for the disposal of virtually all process wastes (with the exception of 2,4,-D wastes) until they were decommissioned in the mid-1980's (CRA 1991). Adjacent to this site was an area for disposal of 2,4,-D waste (RPW-4) (CRA 1996).

Stations 0+732 and 0+750, near the downstream end of the west channel, had higher levels of DDT and metabolites than at the upstream end (0+565). In 1996 samples, surficial sediments

(0-10 cm) at station 0+732 and 0+750 (0-7 cm) exceeded the Severe Effect Levels, based on 1995 TOC results. Evaluation of sediment levels relative to sediment guidelines will be included in the final report, to be issued when all chemical analyses have been completed. The data for station 0+732 suggests that the highest levels are in the 5-10 cm section (1995 results: only 0-10 cm section was sampled in 1996) and that levels decrease significantly in the deeper sections (20-30 cm).

The low concentrations in all core sections at station 0+710, suggest that deposition, rather than subsurface movement with groundwater, is the primary source of DDT at stations in this section of the creek. Station 0+710 was located in the middle of the west channel and hence in an erosional area, while station 0+732 was sampled along the bank in a small, shallow embayment. There was some accumulation of fine-grained sediments (approx. 2-3 cm) in the surface material, which was mainly sand, to approximately 10 cm depth. Below this depth was more consolidated sand-silt material, which gave way to clay at the bottom of the core. The strong discolouration of the bottom section of the cores and the strong chemical odour in these sections suggests contaminated groundwater flow into this area. There was no discolouration of the surface material at station 0+732, but cores from station 0+710 were stained throughout their length. The lack of DDT compounds in these deeper sections, then, suggests that groundwater is not a source.

A similar distribution with depth was found at station 0+750, where the highest levels were in the top layer (0-7 cm). At this station, the entire sediment core, to approx. 15 cm, was unconsolidated silt and sand. The nature of this material suggests recent accumulation from upstream sources and could include currently active sources such as seeps and washout from the land, as well as erosion from upstream depositional areas or banks. The 1996 data for station 0+750 suggests accumulation of DDT compounds is recent, and is an ongoing concern.

The variation in sample results for both station 0+750 and station 0+785 between the different sampling periods suggests that distribution of DDT compounds in these sediments is uneven, and is likely related to variations in patterns of deposition and erosion as flows fluctuate.

The pattern that emerges for DDT shows that upstream areas on the property had higher levels of DDT in the deeper layers, while downstream areas had higher levels in the surface layers. The implications are that one source of these contaminants lies in the upstream section of the property.

The stratification of DDT concentrations with depth suggest that in most areas along the east side of the creek, accumulation of deposited sediments is the primary mechanism by which DDT has occurred in creek sediments. The data suggests that there is broad distribution of DDT compounds in creek sediments adjacent to the Uniroyal site and that pockets of very high (in excess of the SEL) DDT concentrations occur primarily in the depositional areas.

Both sediment sampling and bank sediment/soil sampling indicated that high levels were found above the weir on the west side and, in particular, downstream of the weir in the area of station 0+310 and 127-S. Very high sediment concentrations of DDT compounds were found in bank soils at the latter, and suggest there may be more extensive contamination of the deeper soil levels in this area. As noted previously, past discharges of process wastewater could have resulted in deposition of DDT compounds in the soils and sediments. Disposal of creek sediments on the creek banks during the 1950's may also have contributed contaminated sediments to this area. In addition, monitoring studies conducted by CRA (1996) found detectable levels of DDT in monitoring wells in this same area, suggesting that DDT may be present in the groundwater. Seepage of groundwater from the waste pit area upstream of the dam may have concentrated soil contamination in this area, and may also have resulted in transport of contaminants to the creek. Transport with the ground water could have been facilitated through the presence of solvents, such as toluene, which would help mobilize otherwise hydrophobic compounds in the sediment/soils. Through erosion of bank soils, this area has contributed DDT compounds to depositional areas of the creek, such as the back eddy at station 0+360.

The depositional areas, mainly those quiescent areas at stations 0+360 and 0+750, and to a lesser extent at station 0+732 suggest a history of deposition and accumulation of DDT and metabolites.

Elevated sediment concentrations of DDT

compounds below Shirt Factory Creek, suggest that this creek may have been a source as well. The discharge of wastewater from the Building 8 sump to Shirt Factory Creek during the 1940's is considered the most likely source.

High levels were also detected at station 0+630W. This area is typically exposed during low water periods, but is submerged during higher flows. While it is possible that some deposition of material occurs while the water level is receding and material drops out of suspension, the primarily sandy sediments suggest accumulation of fine-grained sediments is relatively minor and likely transient. The high concentrations encountered, as well as the strongly discoloured water seeping up from the sampling holes, suggests that groundwater should be looked at as a possible mechanism of DDT transport in this section. (This section of the property has been identified has having very high levels of solvents in the groundwater, which could transport these contaminants (CRA 1996)). Areas downstream where elevated concentrations of DDT compounds were detected all appear to be depositional.

Dioxins and furans

The 1995 study (Jaagumagi and Townsend 1996) noted that 2,3,7,8-T_4CDD was the most prevalent dioxin compound in creek sediments adjacent to and downstream of the Uniroyal site. Contamination of creek sediments with dioxins and furans upstream of the Uniroyal plant was very low in comparison.

The 1995 study found low concentrations of dioxins and furans in the impoundment area, though elevated levels of 2,3,7,8-T_4CDD were detected downstream of the weir at station 0+270 (Table 6).

The 1996 sampling also found low concentrations of dioxins upstream of the plant site. (Figure 19 shows the distribution of 2,3,7,8-T_4CDD in creek sediments and bank sediments/soils. Figure 20 shows distribution of total TEQ). In 1995, station 0+244 was sampled approximately 5 m upstream of the weir. Since dredging has recently (1994) been undertaken in the impoundment, it is likely that sediments at station 0+244 do not provide an adequate history of deposition and contaminant accumulation. As noted in Table 1, sediments at this location were primarily sand and silt overlying gravel whereas, sediments at station 0+240E, which was adjacent to the weir, were mainly silts overlying a deeper clay layer. These sediments would be considered typical of depositional areas, unlike the sands and gravels at station 0+244. If dioxins and furans have entered the impoundment, it would be difficult to ascertain, given the history of disturbance of this area.

As noted previously, waste disposal pits were formerly located in the vicinity of monitoring well OW94-4, along the west side of the impoundment. Records indicate that both DDT and 2,4,-D wastes were disposed of in these pits, and that no cleanup was undertaken in this area once the pits were closed (CRA 1991). Since the pits were unlined and the overflow from the pits was directed to Canagagigue Creek, the potential for contamination of adjacent soils and creek sediments is high. There is also potential for seepage of contaminant residues with groundwater, as well as erosion of contaminated soils. While documented groundwater movement indicates there is little movement from the pits into the impoundment area, surface runoff of contaminated soils would drain into the impoundment. In addition, if soils adjacent to the creek are contaminated, then erosion from the bank face could also result in movement and deposition in the impoundment area.

Past accumulation of dioxins and furans in the sediments in the impoundment could also account for the higher levels in sediment at station 0+270. Not all suspended sediment would be deposited behind the weir, and some would be washed over the weir, especially during higher flows. This could result in deposition of contaminated sediments in quiescent areas downstream. This, in addition to documented groundwater movement, could transport both DDT, which has been detected in groundwater samples from this area, as well as dioxins and furans.

The first major quiescent area downstream of the impoundment, and hence the first major depositional area, would be the backeddy pool at station 0+360 (east). The higher levels of 2,3,7,8-T_4CDD and OCDD indicate accumulation from upstream for both compounds. Similarity of concentrations throughout the length of the core suggests that 2,3,7,8-T_4CDD accumulation in the past has been at a relatively steady rate, since surface and

subsurface concentrations were similar. The higher surface concentrations of OCDD suggest accumulation of this compound is more recent.

The 1995 study (Jaagumagi and Townsend 1996) noted that elevated levels of OCDD have been detected in water from the 0400 discharge, located on the west side immediately below the weir. This could account for the higher OCDD concentrations in sediments at station 0+270 and 0+360. OCDD is not a major constituents of 2,4-D or 2,4,5-T, and thus was not present at elevated concentrations in upstream sediment samples.

Downstream of the culverts, station 0+397 (east side) in 1995 had elevated levels of 2,3,7,8,-TCDD. Re-sampling of this area in 1996 yielded a concentration of 22 ppt, which was similar to 0+360. Both are depositional areas, though the fine sediment layer at 0+397 was very thin (<5cm) and was underlaid by sand and gravel. The variation in sample results over the two years, suggests that deposition from upstream is the primary source. The small size of the embayment at station 0+397, and the very shallow depth of fine sediments, suggests that this area is washed out during high water and deposition is on a seasonal basis. As such, it suggests that transport of 2,3,7,8-T_4CDD contaminated sediments in the creek is an on-going concern.

However, the higher concentrations in the bank soils, especially at depth, are not readily explained by deposition from the creek. Bank samples were collected in a grassed area that would be periodically inundated. The soils were cohesive materials, unlike exposed bank areas sampled, where silts typically predominated. This area would justify further investigation.

Concentrations in bank sediments at 0+450 (east) showed slightly higher levels in surficial layers, and similar concentrations in the 10-20 cm layer (Table 9). Levels in bank sediments at 0+590 (east) were somewhat lower in both the surficial sediments and the deeper sediments than levels in the creek. Since in both cases, cores were taken in the exposed sediment, and not on top of the bank, it is likely accumulation is through deposition of fine sediments from the creek during higher flows. However, the possibility that soils along the east side are contaminated with low concentrations (5-15 ppt) of 2,3,7,8-T_4CDD from atmospheric deposition or past disposal practices cannot be discounted.

Station 0+494 (west), below the confluence of Shirt Factory Creek, appears to suggest that deposition of 2,3,7,8-T_4CDD is from sediments carried down the main channel, since levels in Shirt Factory Creek were much lower (Table 6). However, since sediments in Shirt Factory Creek below the plant were mainly sands and gravels (Table 1.1), suggesting periodic high flows occur in the creek, very little accumulation of fine sediments would occur in this section. Therefore, any contaminants originating in Shirt Factory Creek would be deposited downstream in quiescent areas, such as at station 0+494.

While stream sediment concentrations were in the range of 15 ppt at 0+565 (west), bank sediments during both 1995 and 1996 were approximately 2 times higher (Table 9). Again, while this area is submerged at times, there is the possibility that some accumulation of fine sediments has occurred during the transition from high water to low water. However, during high water, there would also be a net erosion of bank materials.

Bank sediment concentrations were typically lower than stream sediment concentrations at stations along the east side, where accumulation from upstream sources appears the most likely source. Accumulation of sediment from upstream sources does not explain why bank sediments would be so much higher than stream sediments at stations along the west side, such as at station 0+565. Monitoring by CRA (1996), has noted that there is seepage of volatiles in this section which is adjacent to the location of the former waste lagoons. Visual observation (Table 1.2) found that sediments below approximately the top 1 cm were black in colour and emitted a strong chemical odour. Leaching and transport of dioxins and furans with solvents in the groundwater would provide a more likely explanation for the high concentrations in bank sediments.

Sediment concentrations of 2,3,7,8-T_4CDD were generally lower at stations along the east side, down to 0+750, with concentrations of 2,3,7,8-T_4CDD in the 5-15 ppt range (stations 0+450, 0+630E, 0+720E and 0+738). Station 0+590 had slightly higher concentrations in 1995, ranging up to 23 ppt. These suggest that distribution of 2,3,7,8-T_4CDD is relatively broad over the site, and slightly

higher in larger, depositional areas such as 0+590. Bank sediment concentrations were typically lower than stream sediments at each location sampled (0+450 and 0+590).

The high concentrations in the subsurface sediments at stations 0+710 and 0+732 suggest that groundwater movement is a significant factor. The heavily stained deeper sections of the cores at station 0+732 contained higher concentrations of 2,3,7,8-T_4CDD than did the surface layer. At station 0+710, there was a steady increase in 2,3,7,8-T_4CDD down to 30 cm, from 71 ppt in the top 10 cm to 290 ppt in the 20-30 cm section. Below 30 cm, where clay predominated, levels were much lower, though some 2,3,7,8-T_4CDD was still detected (24 ppt).

Station 0+750 was located in a depositional area in a backeddy at the downstream end of the west channel. Concentrations of 2,3,7,8-T_4CDD were higher in deeper sections, though cores could only be obtained to a depth of 14 cm. In terms of source of contaminants, this area is not as clearly defined. The loose unconsolidated nature of the sediments suggests that this area is mainly depositional. The higher concentrations in the deeper sections may indicate that deposition in the past has been higher, though the dynamics of this area are unknown. The loose nature of the sediments suggests that during high water, re-suspension of sediments would occur and this area may also be a source of contaminated sediments to downstream areas during high flows. The presence of organic detritus throughout the depth of the core indicates substantial mixing of the sediments occurs as material is deposited and re-suspended.

Concentrations in bank core samples at station 0+800 (east) were relatively low but detectable levels of 2,3,7,8-T_4CDD were still found. Levels were lower than other exposed bank areas along the east side. Sediment concentrations were very low and are likely a reflection of the high sand and gravel, which characterizes this area as erosional.

Concentrations of 2,3,7,8-T_4CDD downstream of the Uniroyal site were generally less than 10 ppt, with the exception of the deeper section at station 20, where concentrations reached 25 ppt. This, again, was a depositional area, and the higher concentrations may reflect higher historical levels of release. The downstream sampling does show, however, that concentrations in creek sediments downstream to the Grand River remain elevated when compared to upstream concentrations.

4.2 Floodplain Sediments/Soils

While DDT and metabolites were detected in sediments at all sampling sites, the distribution in the floodplain areas did not show a consistent pattern (Table 10; Figure 14). In most studies where contaminants originate from a point source, concentrations would be expected to decrease with distance from the source. However, in the floodplain samples some stations further downstream had higher concentrations than stations near the site. This is likely due to a number of physical variables that affect dispersion of contaminants on the floodplain. The height of the pond above the river level, as well as the distance from the creek, are major factors that would affect the frequency of flooding in these ponds and hence the lateral dispersal of contaminated suspended sediment.

The relative amounts of total DDT, as compared to the metabolites DDD and DDE, are shown in Figure 21 (expressed as % of all DDT products). There is a gradual increase with distance downstream of total DDT as DDD+DDE (i.e., the metabolic products), as well as an increase with depth. This suggests greater weathering of this material. In contrast, high levels of DDT on the site suggest a more recent origin of this material.

Concentrations in adjacent soils at station FP-3 showed a significant increase over levels in the pond, with DDT concentrations much higher than either of the metabolites and suggests accumulation in floodplain soils to higher levels than occurred in the ponds. However, this is based on the results of only one sample and additional sampling of floodplain soils would need to be undertaken to verify these results. Despite the higher levels in the soils, concentrations of DDT and metabolites were below the Agricultural Land Use criteria of 1,600 ppb for DDT and DDE, and 2,200 for DDD (OMOEE, 1996).

In comparison with creek and bank sediments on the Uniroyal property, levels in floodplain pond sediments were relatively low, and none exceeded the respective Severe Effect Levels.

Dioxin and furan results indicate that many of the stations further downstream had higher concentrations than those close to the Uniroyal site. As with DDT, it is likely that the physical characteristics of the floodplain are the major factors. Concentrations of 2,3,7,8-T_4CDD in many of the ponds were as high as creek sediments on the site (e.g., 33-36 ppt at FP-9, 39-44 ppt at FP-8, and 63 ppt at FP-5). Concentrations in adjacent soils were only measured at station FP-3, and, while lower than concentrations in pond sediments, exceeded the Agricultural Land Use criteria of 10 ppt (total TEQ) as listed in Guideline for Use at Contaminated Sites in Ontario (OMOEE 1996).

Comparison of the pattern of 2,3,7,8-substituted dioxins and furans in the ponds and the west channel (station 0+710) shows the same pattern of distribution (Figure 22) and indicates that the contaminants in the floodplain ponds and the contamination on site originate from the same source.

The results indicate that sediments contaminated with DDT compounds and dioxins and furans have been dispersed over a large area of the floodplain. However, the study suggests that deposition of contaminated sediments during high water is the primary mechanism of dispersal. The lack of change with depth at many of these sites suggests that deposition has been occurring for an extended period of time.

The distribution suggests that in the area immediately downstream there is relatively less deposition of suspended sediment during flow fluctuations. The high banks and confined channel would serve to funnel flow through this area relatively quickly. Further downstream, where the floodplain widens out and the banks are lower, there appears to be greater deposition. This would be consistent with the physical configuration of the floodplain. The wide floodplain would permit greater deposition in this area due to attenuation of creek flows during flood conditions, and favour the settling of suspended sediment on the floodplain. The high water would also be the period of greatest potential erosion of sediments from the Uniroyal site.

The increase in concentrations of DDT compounds with depth suggests that deposition in the past has been higher, while the dioxin and furan results suggest there has been little change in the rate of deposition of these compounds.

Two mechanisms could account for the higher concentrations in ponds relative to surrounding soils. As the water levels recede, suspended sediment carried onto the floodplain could become concentrated in depressions, and could account for the higher concentrations in floodplain ponds relative to surrounding soils. In addition, sediments deposited on the floodplain could be washed into the ponds during subsequent rainfall events.

The very low water concentrations of dioxins in the ponds is consistent with the nature of these compounds. Dioxins and furans are hydrophobic compounds with an extremely low solubility in water and as a result would rapidly partition to sediment organic matter. The increase in water concentrations of dioxins and furans after the pond had been disturbed is due to re-suspension of bottom sediments. Due to the low solubility of these compounds, availability of dioxins and furans from sediment ingested by animals drinking from the pond is likely to be low. However, this cannot be determined with any certainty based on the data available from this study. Livestock watering guidelines for dioxins (Canadian Water Quality Guidelines) are 39 pg/L, while the highest TEQ for the pond water samples, after disturbance of the water column, was 0.88 pg/L.

4.3 Benthic Tissue Residues

Tissue residue levels strongly suggest there is accumulation of 2,3,7,8-T_4CDD from sediments by biota. Levels in dragonfly nymph tissues were similar to sediment concentrations on a dry weight: dry weight basis (Table 16). Figure 23 shows tissue levels relative to sediment concentrations. As shown in Figure 24, most of the uptake was of 2,3,7,8-T_4CDD and 2,3,7,8-T_4CDF, where tissue residues, when converted to a dry weight basis, were higher than sediment concentrations. There was also uptake of some hepta- and octa- CDDs and CDFs. At station 0+750 (Figure 25), organisms accumulated both 2,3,7,8-T_4CDD and T_4CDF to higher concentrations than were found in sediment, while accumulation of hept- and octa- congeners was low. Both show that 2,3,7,8-T_4CDD and T_4CDF are available to resident benthic organisms and are being accumulated in their tissues.

Tissue residues were higher in those locations where higher sediment concentrations were found. Since the organisms tested were first-order predators, this is not a direct measure of availability from sediments, but rather, indicates that those organisms that feed upon sediment consumers, can, during the course of their aquatic life history, accumulate significant tissue residues. Since these organisms in turn serve as prey to bottom-feeding fish, there is potential for transfer of contaminants such as 2,3,7,8-T_4CDD up the food chain. It also suggests that sediment consumers are accumulating 2,3,7,8-T_4CDD in their tissues.

Given the nature of the test, these most likely originated from the sediments. Since dragonfly nymphs are predators on other benthic organisms, a direct sediment uptake vector cannot be established. However, since they feed primarily on those organisms that ingest sediment, and since the larvae of the Libellulidae burrow into the loose sediment, it appears most likely that sediment, and not the water column, is the source of the dioxins and furans.

4.4 Benthic Community

Stations upstream of the Uniroyal property can be considered as defining the basic condition of the stream, and hence the benthic community that could be expected in depositional areas. The community in these areas is indicative of organic enrichment that is most likely due to agricultural runoff. Thus, the stream can be considered as impacted in comparison with more natural streams.

Depositional areas in the creek were preferentially chosen, since these would result in greatest accumulation of fine sediments to which most persistent organic compounds will bind. These areas also have a characteristic benthic fauna, typified by sediment burrowing and ingesting forms. The most common of these are the chironomids and oligochaetes, species of which are found in a variety of depositional habitats. In most cases, these are numerically the most abundant species.

The benthic community in upstream areas, where contaminant concentrations were typically below detection limits, were dominated by oligochaetes and chironomids (Tables 14 and 15).

The differences between the two upstream stations suggest a high level of inherent variability, which is typical of benthic communities. While the density of organisms varied considerably, the primary taxonomic groups represented were similar at both locations. However, the species composition of the oligochaetes at station 1 relative to station 0+30 suggest a relatively higher degree of organic enrichment at the former, and is not surprising given the agricultural usage of the lands adjacent to the creek.

The benthic community in the impoundment area showed no discernable effects, despite DDT levels of up to 2,800 ppb at station 0+244.

There were changes detected in the composition of the benthic community downstream of the impoundment at station 0+270. In two of the replicates, the chironomid community was absent, and may be a result of the higher DDT concentrations at this station, which at the time of benthic sampling were above the Severe Effect Level for DDT. DDT concentrations at this station were the highest of any of the sites sampled.

The next downstream location where high contaminant concentrations were noted was at station 0+360. Subsurface concentrations of DDT were very high at this location. However, concentrations were close to detection limits in the top 10 cm and this is the zone to which most benthic organisms are limited due to the lack of oxygen penetration into the deeper sediments. Therefore, while high concentrations were found, most benthic organisms would not come into contact with the deeper contaminated material.

There was no detectable effect on the benthic community at station 0+397 despite higher sediment concentrations of dioxins. The lack of measurable effects suggests that the concentrations encountered here do not have a direct toxic effect on benthic communities.

The noticeable absence of the oligochaete community, and the reduction of the chironomid community at station 0+630E suggest the presence of a contaminant effect. While DDT and dioxin concentrations were comparable to other contaminated areas of the creek, where no biological response was noted, the presence of seeps along the bank, as well as the strongly discoloured sediments

suggests other compounds are eliciting the observed response. CRA (1996) has identified high levels of volatile organic compounds in ground water along the west (opposite bank) in this section of the creek. The discoloured sediment typical of the west channel also stretches under this portion of the creek and sediments at this station were both black in colour and gave off a strong odour. The presence of volatile compounds could account for the absence of sediment burrowing forms, which were particularly abundant upstream, and are also abundant downstream.

A similar response by the benthic community was noted at station 0+732. At this location, the chironomid fauna is noticeably reduced, and burrowing forms were absent in 1996. Since the exact same location was not sampled in each year, some differences are anticipated. However, the significant change in chironomid communities between the two years is difficult to explain on that basis alone, particularly since the oligochaete communities were similar, which suggests that habitat type was also similar. Both DDT and dioxin and furan concentrations were higher at the 1996 location and, as at station 0+630E, other compounds may be influencing the benthic community as well. The sediment collected in 1995 had no apparent odour, while in 1996, a strong chemical odour was detected in surface sediments.

Concentrations of sediment-bound contaminants, such as DDT and dioxin compounds, at station 0+732 were similar to other contaminated areas of the creek, where no biological response was detected and suggest that the change in the benthic community is not due to these compounds. As at station 0+630E, discolouration of these sediments was noted as well as the presence of the strong chemical odour.

The reduction in density of both chironomids and oligochaetes at station 0+750 in 1996, as compared to 1995, as well as the change in the chironomid community, suggests the presence of a biological effect. However, the effect can be judged not as severe as at stations 0+630E and 0+732 (1996), since some burrowing forms, such as *Chironomus* were present. It should be noted that surficial DDT and dioxin and furan concentrations were higher in the 1996 samples than in 1995 samples and exceed the Severe Effect Level for DDT.

The data suggest that, on the whole, sediment bound contaminants did not affect the benthic community through changes in community structure. In some areas of high sediment DDT there was no apparent effect on the benthic communities, whereas in other areas of lower, but still elevated DDT concentrations, there was a marked change in species composition. Webber *et al.* (1989) found that the chironomid and oligochaete communities were apparently unaffected by DDT concentrations in sediment that ranged up to 2000 ppm. In contrast, Long and Morgan (1990), in a compilation of biological effects data, found that above 350 ppb of total DDT (includes metabolites), biological effects could be anticipated. Therefore, while Webber *et al.* (1989) attributed the lack of a community response to resistance in the organisms, it is quite likely that availability from the sediments is the major factor controlling toxicity of DDT compounds. In addition, organisms can accumulate tissue residues of persistent organic compounds from sediments, that can be below toxicity thresholds. In such cases, the population itself may not suffer any apparent adverse effects.

Areas where chironomids clearly suggested a response, were located in the section of the property identified by CRA as the primary seepage area, and had highest concentrations of volatile organics, such as toluene and benzene. Since those locations where the benthic community was affected had both high sediment contaminant concentrations and high concentrations of volatiles in the groundwater, the cause of reductions in density and diversity cannot be ascribed to any one cause with any confidence. The lack of similar responses in the benthic community in those areas where only persistent organic compounds were present at high concentrations, suggests that other contaminants, such as the volatile organics, are having the greatest impact.

4.5 Sediment Bioassay

A range of toxic effects was evident among the test sediments, using a battery of test organisms. Station 0+630W sediment was highly acutely toxic to *Hexagenia*, *Chironomus* and *Pimephales* in either 10-day or 21-day exposures. Percent mortality reached

over 90% within a 2 or 7-day time frame for the minnow and mayfly toxicity tests, where daily observations were possible. Sediment collected from station 0+750 elicited a 50% lethal response in the two benthic species and a lower but still significant degree of toxicity to fathead minnows (20% mortality). The remaining three test sediments (0+244, 21-S, FP-3), had acceptable and comparable mortality and growth results as those measured in the negative and reference control sediment.

Spearman rank correlation analysis was used to determine the relationship between the biological responses and sediment physical, nutrient and chemical parameters (Table 24). Neither substrate type (e.g. particle size composition), nor nutrient enrichment (e.g. TOC), influenced the survival or growth of any of the test species. However, both of these substrate-related characteristics were found to significantly correlate with chemical distribution patterns. Certain metals were commonly associated with %fines e.g. Al, As, Cr, Fe and Ni, while Hg, Ni and Zn sediment concentrations were more closely related to the sediment TOC fraction. On a bulk contaminant basis, each of the five toxicity endpoints was negatively correlated with sediment g-BHC concentrations. Concentrations of g-BHC were fairly low, sometimes measured below the detection limit of 1 ng/g and not considered a key toxicant. Similarly, TOC-corrected Hg and Zn sediment concentrations were significantly negatively correlated with several of the test endpoints, but given the low levels present in the sediment, is not considered to be influential in terms of acute toxicity.

Among the pesticides, only op- and pp-DDT sediment concentrations positively correlated with substrate type e.g. % fines. This suggests different factors are contributing to the spatial distribution of the parent compound, DDT, relative to the metabolites (DDE and DDD). Factors such as proximity to point sources and subsequent dispersion have been discussed at length elsewhere in this report. Mayfly and midge survival was negatively correlated with sediment pp-DDD sediment concentrations at $p < 0.05$ or $p < 0.10$. Only pp-DDD achieved concentrations in the test sediment above the respective PSQG-SEL concentration (corrected for OC). Statistical significance between the survival of both benthic species and pp-DDD sediment concentrations was moderate to slight, and is not suspected of being directly accountable for the acute toxic effects. The parent compound (DDT) is considered to be the more toxic form (OMOE, 1992) and ironically, those stations with higher concentrations of op- and pp-DDT did not result in either impaired growth or reduced survival. Sediment concentrations of op + pp-DDT were 175 and 870 ng/g for stations 0+244 and 21-S, respectively. These values were higher than those found at station 0+630W (115 ng/g) and 0+750 (85 ng/g).

A review of sediment toxicity studies conducted at sites with known DDT (DDD,DDE) contamination was completed to provide useful information on effect-level concentrations. Swartz *et al.*, (1994) in 10-day laboratory sediment toxicity tests using the marine amphipod, *Eohaustorius* sp. established a LC50 sediment concentration of 2500 μg/g OC for ΣDDT. ΣDDT is defined as the sum total of DDT, DDE and DDD sediment concentrations. Similarly, work by Hoke *et al.*, (1994), reported a 10-d LC50 ΣDDT sediment concentration of 2580 μg/g OC, using the freshwater amphipod, *Hyalella* sp.. The test sediments used in this study had ΣDDT sediment concentrations ranging from 1.2 μg/g OC to 199 μg/g OC, and were at least an order of magnitude lower than those concentrations expected to cause 50% mortality, according to the literature values. Although the cited LC50 values pertain to amphipod toxicity, it is expected a similar effect-concentration will also apply to midges. Phipps *et al.*, (1995), showed a similar sensitivity between *Hyalella* and *Chironomus*, to water-borne concentrations of DDT, DDD and DDE, on individual compounds. Swartz *et al.*, (1994), also calculated a 10-d threshold sediment concentration of 300 μg/g OC for ΣDDT. In other words, sediment concentrations at or above this amount are apt to result in a significant lethal effect relative to the control mortality rate. Once again, none of the Canagagigue test sediments surpassed 300 μg/g OC ΣDDT.

The MOEE conducted an environmental assessment of sediments from Canagagigue Creek in 1987 as part of the MISA pilot site study (Jaagumagi *et al.*, 1991). Included in the evaluation was a series of laboratory sediment bioassays which examined short-term acute lethality to fathead minnows and mayfly nymphs. The test sediments contained DDT, DDD and DDE concentrations that closely resemble those tested in 1996 as part of this study. At maximum bulk sediment concentrations of 10 ng/g

for op-DDT, 300 ng/g for pp-DDD, 46 ng/g for pp-DDE and 150 ng/g for pp-DDT, mayfly mortality was negligible. Overall, pesticide toxicity doesn't appear to adequately explain the toxicity results.

Elevated ammonia concentrations (as measured in the overlying water) as a direct or indirect cause of toxicity or stress were also evaluated. Generally, fish are more sensitive to changes in ammonia than benthic species (Hellawell, 1986). The highest average un-ionized ammonia concentrations were found at stations 0+630W and 0+750. Ammonia was eliminated as the causative factor for the acute lethality in the minnow toxicity test for station 0+630W. At the first time interval (< 24 hours), un-ionized ammonia was 0.10 mgNH_3/L and was comparable to the reference control value of 0.09 mg/L. Mortality at station 0+630W was already 46% and no reported losses had occurred in the reference sediment. In addition, these concentrations were substantially lower than the acute 96-LC50 reported by Thurston *et al.*, (1983) of 1.27 - 2.73 mgNH_3/L, for fathead minnows of a similar size. For station 0+750, the un-ionized ammonia concentration was 0.63 mg/L and minnow mortality was 20%. Concentrations, although remaining lower than LC50 concentrations, did surpass the chronic-effect *Pimephales promelas* threshold concentration of 0.27 mgNH_3/L (Thurston *et al.*, 1986). With respect to the midge test, the average un-ionized ammonia concentration 0.81 mgNH_3/L for station 0+750 was lower than the reported water-borne 10-d LC50 of 13.8 mgNH_3/L, at pH 8.6 for *Chironomus tentans* (Schubauer-Berigan *et al.*, 1995). Whiteman *et al.*, (1996) in 10-d solid-phase sediment toxicity tests, measured midge mortality and ammonia concentrations in pore-water and overlying water at pH 6.6 only. Applying information from both papers, a revised 10-d LC50 of 2.2 mgNH_3/L was derived at a test pH of 8.6. Therefore, in both benthic toxicity tests, ammonia is not considered an important toxicant at those levels monitored during the tests.

According to the above empirical data, other factors need to be considered in order to explain the clearly evident differences in toxicity among sites. For instance, there was a relationship between higher DDT sediment concentrations and a higher incidence of organism toxicity at stations 0+630W and 0+750. Laboratory and field notes describe the sediments as being heavily stained and distinct chemical odour. Both sediments were collected from or near known seepage areas, which are subjected to groundwater inputs (Jaagumagi and Townsend, 1996). There is a strong co-occurrence of DDT with other substances acting as carriers e.g. toluene, benzene, aniline, which are associated with the seepage areas. CRA (1996) have measured rubber and solvent-based compound(s) in the groundwater at monitoring wells near site 0+630W (i.e., UOW+610 and UOW+630). The relative differences in ammonia concentrations measured in the laboratory sediment toxicity tests also coincide with areas with higher ammonia groundwater contamination. Solvent-based chemicals are typically volatile but may be toxic at very low concentrations either in the sediment or the water, without discrimination to trophic level.

Tissue residue analysis of fathead minnows exposed to creek sediments for 21 days shows that 2,3,7,8-T_4CDD is available from sediments to bottom feeding fish. Tissue concentrations ranged from 70% to 118% of sediment concentrations. Sediment ingestion, rather than uptake from the water column is the most likely route of accumulation, given the low solubility of dioxins in water. The availability of 2,3,7,8-T_4CDD from sediments to both sediment-dwelling organisms and bottom feeding fish suggests there is concern with accumulation and movement up the food chain of dioxins and furans. Accumulation from downstream sediments, particularly the mainly sandy sediments at station 21-S suggests that sediments outside of the Uniroyal site could be contributing to elevated levels of dioxins in the organisms tested, as well as in sport fish. In the latter, levels above the consumption guideline of 10 ppt have been found in some carp (A. Hayton, Pers. Comm.).

The results of the bioaccumulation component of the sediment bioassay testing found that fathead minnows had accumulated 2,3,7,8-T_4CDD tissue residues at the end of the test. Fathead minnow tissue residues were approx. 10% of the associated sediment concentrations at station 0+750 when compared on a wet weight:dry weight basis. When concentrations were converted to a dry weight basis using the formula in Persaud *et al.* 1987, (Table 22a), tissue residue levels were approximately 70% of sediment levels. Tissue residue levels however, were similar to sediment levels in the one test with floodplain pond sediments (FP-3) and indicate a relatively higher level

of bioavailability from these sediments.

Initial sediment concentrations were much higher in the bioassay sediments relative to field samples, likely due to the selective concentration of fine particulate material due to sieving of the sediment. Persistent organic compounds are known to sorb to fine particulate matter.

There was significant uptake of dioxins and furans from sediments collected from the pond on the floodplain (station FP-3), and suggests a higher availability from these sediments.

The pattern of DDT uptake observed in the laboratory sediment tests (Table 22b) has been corroborated by numerous field and laboratory studies examining organic chemical bioaccumulation in Canagagigue Creek by other trophic levels that exemplified multiple routes of exposure. The greatest level of accumulation is typically found for DDE, followed by DDD. DDT is the least efficient in terms of chemical uptake, regardless of the amount measured in the exposure media. For instance, this trend has been reported for common shiners (Hitchin, 1997), caged freshwater mussels (Hayton and Petro, 1996; Hayton and Petro, 1994), in-situ benthos (Jaagumagi *et al.*, 1990) and laboratory-exposed fathead minnows and mayflies (Jaagumagi *et al.*, 1990).

A combination of chemical and biological factors can help explain the higher affinity of DDE and DDD for organism tissues. Vertebrates such as fish have been shown to have an efficient metabolic enzyme system, known as the mixed-function oxidase or MFO system that is capable of transforming parent DDT into the metabolites DDD and DDE (Schmitt *et al.*, 1985; Wang and Simpson, 1996). This may help explain why the DDE minnow concentration observed at station 0+750 was found at measurable levels, although the sediment DDE concentration remained very low. The source of the DDE in fish could have arisen from uptake of DDT from the sediment and the subsequent conversion into DDE.

The direct uptake of DDE from water and sediment by aquatic organisms can be attributed to its chemical properties. DDE is highly bioaccumulative, resistant to further degradation in tissue, highly lipophilic and is more water soluble than DDT (MOEE, 1992). The smaller molecular size of DDE (318 MW) may also facilitate movement across biological membranes relative to DDT (354 MW).

The wildlife protection guideline for ΣDDT in fish flesh is 200 ng/g (wet weight) (Newell *et al.*, 1987). This criteria was set to aid in the protection of higher trophic levels including birds and mammals that may biomagnify DDT through the ingestion of contaminated fish. Laboratory tests would represent a worst-case situation for uptake from sediment but the 21-day fish residues may not necessarily reflect steady-state or maximum concentrations. The final ΣDDT fish concentrations ranged from 120 to 166 ng/g (wet wt) at the two test locations. These concentrations are about one-half the NYSDEC guideline and do show some capacity for bioaccumulation. Analysis of resident fish would be a better indicator of concentrations achieved over the long-term (Hitchin, 1997).

The results of the bioaccumulation studies indicate that control of sources of dioxins and DDT compounds would reduce the availability of these compounds to biota, and should be a priority in any remediation plans for the site. Removal of the sources would greatly reduce tissue accumulation, though those organisms with elevated tissue residues would likely not depurate dioxins and furans. As a result, elevated levels of dioxins and furans in organism tissues may persist for some time, even when sources have been controlled. However, controlling the sources of new accumulation should significantly reduce the accumulation rate in younger organisms.

While many areas of the creek downstream of the Uniroyal site currently appear to serve as sources through the accumulation of contaminants in fine sediments, these areas are likely transient. Flushing of accumulated sediment on an annual basis would result in re-suspension and downstream transport of much of the sediment that has accumulated in quiescent areas below the Uniroyal site. This material would be rapidly diluted in the Grand River and is not likely to contribute to elevated tissue levels.

5.0 CONCLUSIONS

1. The results of the sediment investigation indicate that sources on the Uniroyal site have contributed to contamination of sediments along both sides of the creek, from the impoundment area to the Grand River. Contaminant levels are highest on the Uniroyal property, and contaminants appear to be focused in fine sediments in depositional areas.

2. Exposed bank areas of the creek on the Uniroyal property are also contaminated with DDT and dioxins and furans. In some areas, this is likely due to sediment re-suspension and deposition during flow fluctuations. In other areas, movement of contaminants with contaminated groundwater is suggested. In addition, contaminated materials from dredging of the impoundment in the 1950's were disposed of adjacent to the creek in the northwest section of the property.

3. Sources of DDT compounds are indicated in the impoundment area, and immediately downstream in the small west channel. The former waste pits are strongly implicated as sources of DDT and dioxins and furans. Very high levels of DDT compounds in the deeper sections of the bank soils may be due to a number of possible mechanisms. Direct discharge of process wastewaters, disposal of creek sediments on the banks and accumulation through groundwater movement may all have contributed to higher contaminant levels. Detectable levels of DDT in groundwater in 1995 (CRA 1996) indicate this migration may still be occurring. This section is, therefore, a potential source through the erosion of contaminated soils and possibly through groundwater transport of contaminants as well.

4. The study results indicate this is the primary source of DDT compounds on the Uniroyal property. Once in the creek, the material becomes focused in depositional areas, with the highest concentrations close to the source, on the Uniroyal property, and lower concentrations downstream. The large depositional areas appear to have a long period of accumulation. The higher concentrations with increasing depth suggest that losses of DDT compounds to the creek have been higher in the past. The variation in concentrations from year to year in the small depositional areas suggests that most of the sediments are transient and are re-suspended during higher flows. Areas of the creek, down to the Grand River, appear to be contaminated with low concentrations of DDT products.

5. Levels of DDT compounds increase below Shirt Factory Creek, likely as a result of discharge of process wastewater during DDT production. In addition, some DDT may also have been transported with contaminated groundwater in the west channel, at and below the former waste lagoons.

6. Sources of dioxins in or below the impoundment area are suggested by higher concentrations in depositional areas and stream bank areas immediately downstream. The location of these cannot be determined with any accuracy, but historical records of the waste pit at RPW-1, suggest this could be a source. Sources are also identified for OCDD below the 0400 discharge. The main sources of 2,3,7,8-T_4CDD appears to be along the west channel, in the southwest section of the property. At the latter, movement of contaminated groundwater appears to be a significant transport mechanism.

7. Upstream of the weir the transport mechanisms cannot be determined with the information currently available. Downstream, along the southwest section of the property adjacent to and downstream of the former waste lagoons, the primary mechanism of transport to the creek appears to be movement with contaminated groundwater. The increase in concentrations of 2,3,7,8-T_4CDD with depth, particularly in areas characterized as erosional, strongly suggests that groundwater has and may continue to act as a transport mechanism. The depth and degree of contamination of these sediments indicate they will continue to act as a source of contamination to downstream areas through erosion.

8. In addition, many areas of the banks on both sides of the creek appear to be contaminated

with 2,3,7,8-T_4CDD, as well as DDT compounds, and may reflect resuspension of creek sediments and subsequent deposition in bank areas during high flow conditions.

9. In the creek, the dioxins appear to be deposited in quiescent areas, with the highest concentrations found on the Uniroyal property. Detectable levels, though relatively low, were found as far downstream as the Grand River.

10. In addition, areas of the floodplain appear to be contaminated with both DDT compounds and dioxins and furans. A number of permanent and temporary ponds were sampled, and all had elevated levels of both groups of compounds when compared to upstream locations. The annual flooding of the creek is the most likely mechanism of transport to these areas.

11. Water samples collected in the floodplain ponds suggest that levels in the water are very low, and that most of the dioxins are sediment-bound. Disturbance of the water column resulted in resuspension of bottom sediments. This in turn resulted in detectable levels of some dioxins (but not 2,3,7,8-T_4CDD) in these samples. Levels were below all guidelines for undisturbed water samples, but exceeded the Canadian Water Quality Guideline for the disturbed water sample from station FP-3 (total TEQ was 0.88 pg/L). However, the levels of 0.88 pg/L total TEQ was well below the Canadian Water Quality Guideline livestock watering criterion of 39 pg/L.

12. Soils around these ponds show that TCDD concentrations are lower than in the ponds, but that DDT concentrations are higher and implies that broad areas of the floodplain are contaminated. Due to the hydrophobic nature of these compounds and the strong partitioning to organic carbon, little is generally available to plants (M.Marsh, pers. comm.). However, studies indicate that grazing animals will often remove and ingest roots and attached soils while feeding and this may provide a means of uptake of contaminated soils. Additional work would be warranted in these areas to determine the extent and availability of contaminants to grazing animals.

13. The levels of DDT compounds and dioxins and furans in the floodplain ponds do not appear to be directly toxic to aquatic organisms. Since these ponds have no direct link to the creek, there is likely to be little or no movement of contaminated sediments to the creek. While the major concern with dioxin compounds appears to be bioaccumulation, contaminants in the floodplain sediments would not contribute to elevated levels in sport fish in the creek. The availability of these compounds to terrestrial organisms cannot be assessed on the basis of the information available. However, from an aquatic ecosystem perspective, there is little justification for remedial action in these areas.

14. The benthic communities in depositional areas of the creek were observed for effects of contaminants on benthic community structure. Direct effects of contaminants on benthic community health could not be determined, though at station 0+270, the chironomid community may have been affected by elevated DDT levels. A few areas near the former waste lagoons, where high volatiles concentrations have been detected in groundwater, had significantly reduced benthic communities. This reduction is attributed to the volatiles, and not the sediment-bound contaminants.

15. Benthic organism tissue residues indicate that dioxins are bioavailable in both the creek and the floodplain ponds, and that organisms further up in the food chain (1st order predators) are accumulating tissue residues at levels comparable to those found in sediments. Since carp have been found with high tissue levels of 2,3,7,8-T_4CDD, there is strong indication that there is movement further up the food chain. Since the sediments in floodplain ponds would effectively be isolated from the carp, the on-going sources, as well as contaminated creek sediments, are of primary concern and should be addressed in that order.

16. Sediment bioassay testing undertaken in the lab found rapidly lethal conditions in sediments from the primary seep area. These areas had high levels of volatile organic compounds, such as toluene, in addition to elevated concentrations of DDT compounds and dioxins and furans. Since similar responses were not

obtained in sediment which had similarly high levels of DDT and dioxins and furans, but low levels of volatiles, the latter are most likely responsible for the lethality of the test organisms. Sediments from one location did suggest that the observed reduction in growth in some organisms may be attributable to elevated levels of persistent organic compounds.

17. The primary concern related to elevated contaminant concentrations appears to be bioaccumulation and biomagnification of these compounds through the food chain. This does have direct implications on human consumers of fish from the creek, since carp have been found to have unacceptably high tissue levels of dioxins. Control of sources of this material should be a priority.

Note: DDT tissue residue analysis results for fathead minnows are currently not available. These will be included in the final report.

The process outlined in the sediment quality guidelines has been used to determine that while large areas of the creek have sediments with elevated levels of dioxins and furans, as well as DDT compounds in excess of the Severe Effect Levels, there is no direct toxicity associated with these levels in the laboratory, though there is a suggestion of reduced biological diversity in the field in those areas where DDT compounds were in excess of the Severe Effect Level. Biological testing has found, however, that the compounds are bioavailable and can potentially move up the food chain. Therefore, there are biological effects associated with the contaminant levels. This then necessitates the controlling of sources and may require additional remedial action.

6.0 RECOMMENDATIONS

The Provincial Sediment Quality Guidelines identify a process for evaluation and management of contaminated sediment problems. As noted above, the identification of biological effects requires that management action be undertaken.

The recommendations for subsequent action are based upon the need to control sources before additional action is undertaken through a remediation plan (Jaagumagi and Persaud, 1996).

1. *The upper aquifer containment system should be brought on line and be fully operational as a first step in undertaking remedial action on the site.*

Rationale

The primary concern in any remediation effort is to control existing sources. Since movement of groundwater contaminated with volatile organic compounds has been identified as a major potential pathway for persistent organic compounds to the creek, this should be the primary focus of any remedial action. The effectiveness of the containment system should be verified before any additional remedial action is considered. Since volatile organic compounds in the groundwater appear to act as carriers of persistent organics, disturbance of the creek bed through dredging or excavating could potentially release large quantities of contaminants to the stream.

2. *Uniroyal should prepare and undertake, as soon as possible, a plan of action that addresses the former waste pit area adjacent to the impoundment in the vicinity of monitoring well OW94-4. This plan should also address the creek bank in the area where dredged materials may have been placed.*

Rationale

Groundwater sampling, as well as sediment and soil sampling has found DDT residues in groundwater, bank soils and bank sediments both in the vicinity of the former waste pits, and downstream where the groundwater flow re-enters the creek near the 127-S monitoring well. This area appears to act as a source of DDT compounds and, possibly dioxins and furans as well, to the creek. The high levels in bank soils indicate that this area could be a significant source through erosion of contaminated soils and sediments. The possibility of disposal of dredged sediments from the impoundment on the creek bank

would warrant additional soils testing in these areas to determine the extent of contaminated soils.

3. *Additional areas identified as potential sources of contaminants should be thoroughly investigated and if they are determined to act as sources, should be addressed through a remediation plan.*

Rationale

Areas along the creek that in the past received dreadgeate from deepening of the creek should be investigated. The study also found that sediments along the west channel in the southwest section of the Uniroyal property are contaminated with dioxin and furan residues. This section is the area most affected by the Upper Aquifer Containment System. The high sediment residues in this area suggest these sediments could continue to be a source of 2,3,7,8-TCDD to the creek after the containment system is fully operational. Additional biological studies in this area should be undertaken due to the high potential bioavailability and transfer through the food chain which poses potential risks for the human population through the consumption of contaminated fish.

4. *Availability of persistent organics to aquatic organisms should be re-evaluated once the containment system is fully operational, and the additional sources have been controlled, in order to determine if there are changes in bioavailability.*

Rationale

Both DDT compounds and dioxins and furans are hydrophobic compounds. The presence of sometimes very high levels of solvents in the groundwater, as well as sediments and soils on the property, would potentially enhance the mobility and hence the availability of these compounds. The removal of the solvents through the containment system may significantly affect the bioavailability of these compounds. The availability of DDT and dioxin and furan compounds should be determined approximately 6 months after start-up of the Upper Aquifer Containment System. Based on these evaluations, additional remedial action may need to be considered.

5. *Additional coring work in the centre and east channels in the primary seep area is warranted.*

Rationale

To date, sediment evaluation has found elevated levels of 2,3,7,8-TCDD in the west channel to depth of 20-30 cm. The nature of the sediments in the centre and east channels precluded such sampling, and the depth and areas extent of contamination in this area remains largely undefined. Since contaminated groundwater has also reached these areas of the creek, these areas could continue to serve as sources of contaminants to the creek once the containment system is fully functional. However, such work should be undertaken carefully to ensure that coring does not create toxic upwellings of groundwater, since the containment system is not expected to capture groundwater under the creek (J. Warbick, Pers. Comm.).

6. *Investigation of floodplain soils, in particular in those areas used as grazing lands, should be undertaken. At present no additional remedial action is recommended for those areas of the floodplain where higher DDT and dioxin levels were found.*

Rationale

While broad areas of the floodplain are contaminated with both DDT and dioxins and furans, these appear to be largely biologically unavailable. Since there is no direct interchange with the floodplain ponds and the creek, there is little likelihood of contaminated sediments being returned to the creek. However, additional soils and vegetation testing would be warranted, since these areas serve as grazing lands.

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Appendix A

Provincial Sediment Quality Guidelines

Appendix A

PROVINCIAL SEDIMENT QUALITY GUIDELINES

The PSQGs define three levels of ecotoxic effects and are based on the chronic, long term effects of contaminants on benthic organisms. The essence of the guidelines and their significance are summarized below.

1. A No Effect Level at which no toxic effects have been observed on aquatic organisms. This is the level at which no biomagnification through the food chain is expected. Sediments at the No Effect Level would be considered clean.

2. A Lowest Effect Level indicating a level of sediment contamination that can be tolerated by the majority of benthic organisms. Sediments at this level would be considered clean to marginally contaminated.

3. A Severe Effect Level indicating the level at which pronounced disturbance of the sediment-dwelling community can be expected. This is the sediment concentration of a compound that would be detrimental to the majority of benthic species. Sediments at this level would be considered heavily contaminated.

EVALUATION OF SEDIMENT QUALITY

Initial evaluation of bottom sediment or fill material is conducted by comparing the chemical concentrations of the material to the appropriate parameter values listed in Tables A.1. Material is tested by bulk sediment analyses and results are reported on a dry weight basis.

General Conditions Governing Evaluation

- If the parameter value for a given sediment sample is at or below the No Effect Level Guidelines, the samples passes the guideline. If the parameter value for a given sediment sample is at or above the Lowest Effect Level Guidelines, that material fails the guideline. If the single parameter value for a given sediment sample is at or above the Severe Effect Level Guideline, that material fails the guideline.

- Where a sediment consistently exceeds the Lowest Effect Level or exceeds the Severe Effect Level, additional biological investigation in warranted.

- The MOEE recognizes that long-range sources such as atmospheric deposition have contributed to accumulation of organic compounds in areas remote from any specific source. Therefore, in those areas where specific sources cannot be determined, the practical lower limit for management action is the Upper Great Lakes deep basin surficial sediment concentration.

SPECIFIC CONDITIONS GOVERNING EVALUATION

Areas of Potential Concern

When sediment quality in an area consistently exceeds the Lowest Effect Level Guideline, that area shall be considered as an area of potential concern, and the sediment evaluation procedure outlined below shall apply.

The sediment evaluation procedure described below outlines in detail the procedure in Figure A.1.

- The sediment concentrations for all parameters are compared to the PSQGs and if sediment analysis shows that the concentration of a parameter is below the Lowest Effect Level, the sediment can be considered as clean and no further management decisions are required.

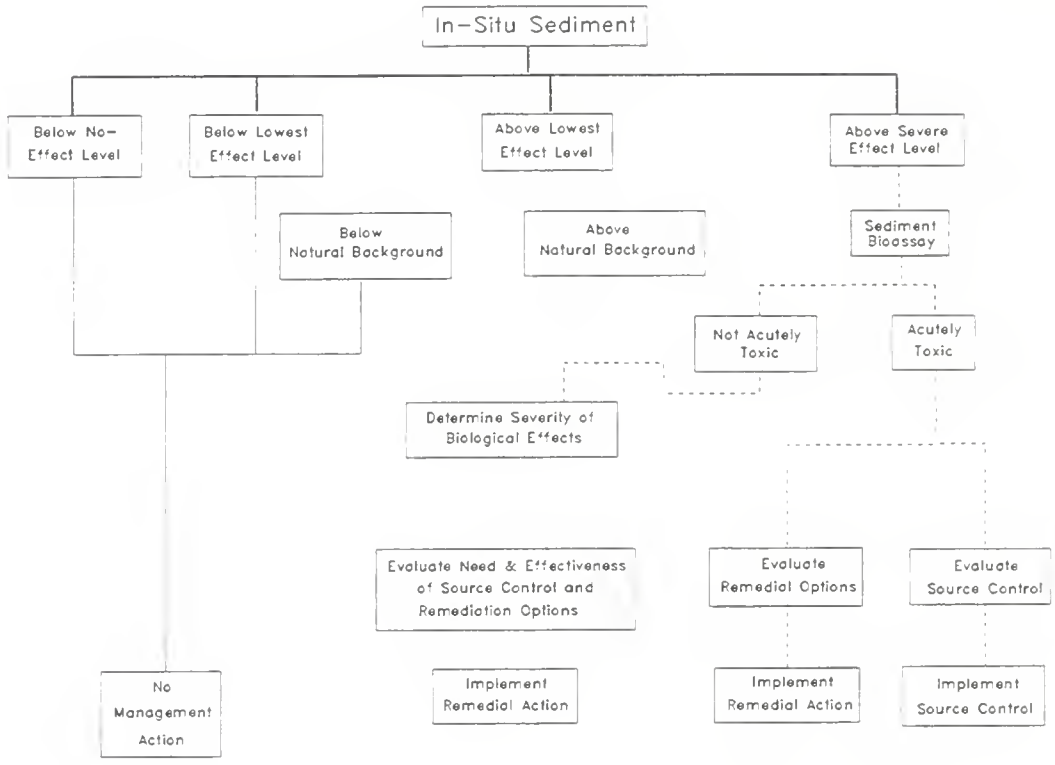


Figure A.1: Application of Provincial Sediment Quality Guidelines to Sediment Assessment

- If the sediment concentration exceeds the Lowest Effect Level, then the concentration is compared with the local background values for that parameter.

- If the sediment concentration is below the natural background then no further management action should be required.

- If the sediment concentration exceeds the local background value, then the next step is to determine whether the sediment poses a threat to aquatic life, and if so, the severity of this effect. A number of biological assessment techniques would be expected to be used in such an assessment. These should encompass laboratory and field-based measures on both individual toxic effects as well as "ecosystem" measures.

- If the concentration of the contaminant in the sediment exceeds the Severe Effect Level then the MOEE Sediment Bioassay tests described in Bedard *et al.* 1992, designed to assess whether the sediment is acutely toxic, are required.

In areas where contaminants in sediment are at or above the Severe Effect Level, the sediment is deemed to be highly contaminated and measures in addition to source control may be required to clean up the sediment.

Table A.2: Interim Sediment Quality Guidelines for Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans

Compound	Partition Coefficient $\log K_{oc}$	Water Quality Criterion (Tentative)	I-TEF	Guideline	Effect Level
2,3,7,8-T_4CDD	6.83	0.38 pg/L	1	25.7 ppt	No Effect Level
1,2,3,7,8-P_5CDD	7.27	0.38 pg/L	0.5	354 ppt	No Effect Level
1,2,3,4,7,8-H_6CDD	7.67	0.38 pg/L	0.1	1.8 ppb	No Effect Level
1,2,3,6,7,8-H_6CDD	7.58	0.38 pg/L	0.1	14 ppb	No Effect Level
1,2,3,7,8,9-H_6CDD	6.69	0.38 pg/L	0.1	186 ppt	No Effect Level
1,2,3,4,6,7,8-H_7CDD	7.86	0.38 pg/L	0.01	27.5 ppb	No Effect Level
O_8CDD	8.06	0.38 pg/L	0.001	436 ppb	No Effect Level
2,3,7,8-T_4CDF	6.56	0.38 pg/L	0.1	138 ppt	No Effect Level
1,2,3,7,8-P_5CDF	7.67	0.38 pg/L	0.05	8.9 ppb	No Effect Level
2,3,4,7,8-P_5CDF	7.32	0.38 pg/L	0.5	396 ppt	No Effect Level
1,2,3,4,7,8-H_6CDF	7.57	0.38 pg/L	0.1	1.4 ppb	No Effect Level
1,2,3,6,7,8-H_6CDF	7.47	0.38 pg/L	0.1	1140 ppt	No Effect Level
1,2,3,7,8,9-H_6CDF and 2,3,4,6,7,8-H_6CDF	6.88	0.38 pg/L	0.1	285 ppt	No Effect Level
1,2,3,4,6,7,8-H_7CDF	8.28	0.38 pg/L	0.01	72 ppb	No Effect Level
1,2,3,4,7,8,9-H_7CDF	6.78	0.38 pg/L	0.01	2.3 ppb	No Effect Level
O_8CDF	8.2	0.38 pg/L	0.001	602 ppb	No Effect Level

Note: Since Provincial Water Quality Objectives/ Guidelines (PWQO/Gs) have not been developed, an interim value has been used to calculate No Effect Levels. The Canadian Water Quality Guideline (CWQG) of 0.38 pg/L total TEQ has been used to derive No Effect Level Guidelines. The above sediment guidelines may change, depending on the final PWQO/G.

No Effect Level guidelines have been converted to a bulk sediment concentration based on a sediment of 1 % TOC.

Given the lack of additional guideline levels, site-specific assessment of biological effects should be conducted to determine the severity of contamination where:

1) Sediment concentrations of 2,3,7,8-T_4CDD exceed the No Effect Level guidelines.

2) Where only a few of the compounds have been detected, the individual PCDDs or PCDFs exceed the No Effect Level guidelines.

3) The total 2,3,7,8-T_4CDD TEQ for all compounds exceeds the NEL for 2,3,7,8-T_4CDD.

Appendix B

Analytical Results for Other Organic Compounds

and Metals. 1995-96

Table B-1: PCB and Organochlorine Pesticide Concentrations in Sediment. Canagagigue Creek. 1995.
All values in ng/g dry weight unless indicated otherwise.

	PCB, total	HCB	Heptachlor	Aldrin	pp-DDE	Mirex	α-BHC	β-BHC	γ-BHC	α-Chlordane	γ-Chlordane	Oxychlordane
June 1995												
Stn C1	20<W	1<W	1<W	1<W	1<W	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+30	20<W	1<W	1<W	1<W	5<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+244	20<W	1<W	1<W	1<W	120	5<W	1<W	1<W	27	2<W	2<W	2<W
0+270	40<T	2<T	1<W	1<W	340	5<W	1<W	1<W	23	2<W	12<T	2<W
0+330C	20<W	1<W	1<W	1<W	11	5<W	1<W	1<W	1<W	4<T	2<W	2<W
0+320	20<W	1<W	1<W	1<W	6	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+330W	20<W	1<W	1<W	1<W	24	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+432	20<W	1<W	1<W	1<W	32	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+397	20<W	1<W	1<W	1<W	28	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+406	20<W	1<W	1<W	1<W	30	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+494	880p54	4<T	1<W	1<W	50	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+565	20<W	7<T	1<W	1<W	37	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+600	20<W	1<W	1<W	1<W	11	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+630W*	20<W	1<W	1<W	1<W	42	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+732	320p54	4<T	1<W	1<W	69	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+738	20<W	1<W	1<W	1<W	13	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+750	200p54	34	1<W	1<W	87	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+785	220p54	1<W	1<W	1<W	75	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Stn 20 0-15	20<W	1<W	1<W	1<W	36	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Stn 20 15-30	20<W	1<W	1<W	1<W	120	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Stn 21	20<W	1<W	1<W	1<W	40	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Stn 22	20<W	3<T	1<W	1<W	45	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Stn 23	20<W	1<W	1<W	1<W	34	5<W	1<W	1<W	1<W	2<W	2<W	2<W

<W = below detection limit <T = trace amount Value = >SEL * stn 0+609 renamed to reflect actual distence

Table B-1: cont'd.

	op-DDT	pp-DDD	pp-DDT	op-DDT + pp-DDT	Methoxy-chlor	Hepta-chlor epoxide	Endosul-phan-I	Dieldrin	Endrin	Endosul-phan-II	Endosul-phan sulphate	Octa-chloro-styrene	TOC mg/g
June 1995													
Stn C1	5<W	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	11
0+30	5<W	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	19
0+244	5<W	100	2800	2800	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	12
0+270	280	370	4000	4280	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	15
0+330C	5<W	45	50	50	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	19
0+320	25	45	45<T	70	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	22
0+330W	200	80	220	440	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	17
0+432	60	120	120	180	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	17
0+397	55	120	120	175	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	21
0+406	65	60	250	315	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	20
0+494	5<W	270	200	200	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	47
0+565	5<W	60	180	180	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	11
0+600	5<W	25	85	85	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	8.4
0+630W	5<W	420	1700	1700	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	12
0+732	75	220	440	525	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	12
0+738	5<W	20<T	30<T	30<T	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	33
0+750	50	180	370	420	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	22
0+785	65	200	1200	1265	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	35
Stn 20 0-15	45	150	1400	1445	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	13
Stn 20 15-30	5<W	380	500	500	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	14
Stn 21	15<T	50	45	60	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	28
Stn 22	25<T	65	360	385	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	16
Stn 23	5<W	40	75	75	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	49

<W = below detection limit <T = trace amount Value = >SEL * stn 0+609 renamed to reflect actual distance

Table B-1: cont'd.

	PCB, total	HCB	Heptachlor	Aldrin	pp-DDE	Mirex	α-BHC	β-BHC	γ-BHC	α-Chlordane	γ-Chlordane	Oxychlordane
October 1995												
0+30	20<W	1<W	1<W	1<W	5<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+285	20<W	1<W	1<W	1<W	180	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+456	120	1<W	1<W	1<W	75	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+565	20<W	1<W	1<W	1<W	46	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+590	20<W	1<W	1<W	1<W	19	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+630W*	20<W	1<W	1<W	1<W	160	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+668	20<W	1<W	1<W	1<W	92	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+732 0-12	20<W	4<T	1<W	1<W	50	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+732 12-25	20<W	2<T	1<W	1<W	1100	5<W	1<W	1<W	1<W	28	2<W	2<W
0+750	20<W	3<T	1<W	1<W	110	5<W	1<W	1<W	1<W	8<T	2<W	2<W
0+785	20<W	5<T	1<W	1<W	35	5<W	1<W	1<W	1<W	2<W	2<W	2<W
November 1995												
0+120 0-8	20<W	1<W	1<W	1<W	8	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+120 8-20	20<W	1<W	1<W	1<W	10	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+438	20<W	1<W	1<W	1<W	1<W	5<W	1<W	1<W	200	2<W	2<W	2<W
0+468	80p40	1<W	1<W	1<W	12	5<W	1<W	1<W	25	24	12<T	2<W
Stn 21 Pond	80p40	1<W	1<W	1<W	160	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Stn 21 Strm	20<W	1<W	1<W	1<W	100	5<W	1<W	1<W	1<W	2<W	2<W	2<W

<W = below detection limit <T = trace amount * stn 0+609 renamed to reflect actual distance

Table B-1: cont'd.

	op-DDT	pp-DDD	pp-DDT	Methoxy-chlor	Heptachlor epoxide	Endosul-phen-I	Dieldrin	Endrin	Endosul-phen-II	Endosul-phen sulphate	Octe-chloro-styrene	TOC mg/g
October 1995												
0+30	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+285	45<T	220	340	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+456	60	24	300	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+565	10<T	190	60	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+590	15<T	150	50	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+630W*	150	480	1100	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+668	60	500	180	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+732 0-12	30	210	300	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+732 12-25	660	5800	2300	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+750	50	260	150	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
0+785	25<T	120	130	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	N.A.
November 1995												
0+120 0-8	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	31
0+120 8-20	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	22
0+438	5<W	45	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	36
0+468	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	35
Stn 21 Pond	5<W	380	580	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	56
Stn 21 Strm	35<T	100	85	5<W	1<W	2<W	2<W	4<W	4<W	4<W	1<W	16

<W = below detection limit <T = trace amount Value = >SEL N.A. = not available * stan 0+609 renamed to reflect actual distance

Table B-2: PCB and Organochlorine Pesticide Concentrations in Sediment. Canagagigue Creek. 1996. All values in ng/g dry weight unless indicated otherwise.

Station	Depth cm	PCB, total	Heptachlor	Aldrin	pp-DDE	Mirex	α-BHC	β-BHC	γ-BHC	α-Chlordane	γ-Chlordane	Oxychlordane
Sediment												
0+30	0-10	20<W	1<W	1<W	2<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+30	10-20	20<W	1<W	1<W	3<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+30	20-30	20<W	1<W	1<W	2<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+30	30-40	20<W	1<W	1<W	4<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+240-E	0-10	20<W	1<W	1<W	3<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+240-E	10-20	20<W	1<W	1<W	4<T	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+244	0-8	20<W	1<W	1<W	8<T	5<W	1<W	1<W	7<T	2<W	2<W	2<W
0+244	8-18	20<W	1<W	1<W	49	5<W	1<W	1<W	6<T	2<W	2<W	2<W
0+345		20<W	1<W	1<W	64	5<W	2<T	1<W	7<T	2<W	2<W	2<W
0+360-E	0-10	20<W	1<W	1<W	20	5<W	1<W	16	3<T	2<W	2<W	2<W
0+360-E	10-20	20<W	1<W	1<W	760	5<W	1<W	17	1<W	12<T	2<W	2<W
0+397		20<W	1<W	1<W	7<T	5<W	1<W	20	2<T	2<W	2<W	2<W
0+450		20<W	1<W	1<W	5<T	5<W	1<W	15	2<T	2<W	2<W	2<W
0+590	0-10	20<W	1<W	1<W	6<T	5<W	1<W	1<W	5<T	2<W	2<W	2<W
0+590	10-20	20<W	1<W	1<W	7<T	5<W	1<W	24<W	2<T	2<W	2<W	2<W
0+630-E		20<W	1<W	1<W	8<T	5<W	1<W	3<T	1<W	2<W	2<W	2<W
0+710	0-10	100P40	1<W	1<W	400	5<W	3<T	3<T	1<W	8<T	10<T	2<W
0+710	10-20	20<W	1<W	1<W	670	5<W	3<T	4<T	1<W	12<T	2<W	2<W
0+710	20-30	20<W	1<W	1<W	1<W	5<W	1<W	5<T	2<T	8<T	2<W	2<W
0+720-E		20<W	1<W	1<W	8<T	5<W	1<W	1<W	7<T	2<W	2<W	2<W
0+732	0-10	80P40	1<W	1<W	160	5<W	1<W	1<W	7<T	2<W	2<W	2<W
0+732	20-30	80P40	1<W	1<W	520	5<W	7<T	4<T	2<T	2<W	2<W	2<W
0+750	0-7	20<W	1<W	1<W	100	5<W	1<W	1<W	7<T	2<W	2<W	2<W
0+750	7-14	20<W	1<W	1<W	59	5<W	1<W	1<W	3<T	4<T	4<T	2<W
0+800		20<W	1<W	1<W	15	5<W	1<W	1<W	1<W	2<W	2<W	2<W
21S	0-10	20<W	1<W	1<W	52	5<W	1<W	1<W	2<T	2<W	2<W	2<W
21S	10-20	20<W	1<W	1<W	89	5<W	1<W	1<W	1<W	2<W	2<W	2<W

Tabla B-2: cont'd.

Station	Depth cm	op-DDT	pp-DDD	pp-DDT	op-DDT + pp-DDT	Methoxy-chlor	Hepta-chlor apoxide	Endosul-phan-I	Dieldrin	Endrin	Endosul-phan-II	Endosul-phan sulphate	TOC mg/g
Sediment													
0+30	0-10	5<W	5<W	5<W	5<W	5<W	1<W	2<W	10<T	4<W	4<W	4<W	
0+30	10-20	5<W	5<W	5<W	5<W	5<W	1<W	2<W	8<T	4<W	4<W	4<W	
0+30	20-30	5<W	5<W	5<W	5<W	5<W	1<W	2<W	8<T	4<W	4<W	4<W	
0+30	30-40	5<W	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+240-E	0-10	5<W	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+240-E	10-20	5<W	5<W	5<W	5<W	5<W	1<W	2<W	8<T	4<W	4<W	4<W	
0+244	0-8	5<W	10<T	40<T	40<T	5<W	1<W	2<W	12<T	4<W	4<W	4<W	
0+244	8-18	15<T	120	160	175	5<W	1<W	2<W	2<W	36	4<W	4<W	
0+345		20<T	90	130	150	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+360-E	0-10	35<T	50	5<W	35<T	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+360-E	10-20	2800	25<T	9500	12300	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+397		5<W	15<T	5<W	5<W	5<W	1<W	2<W	10<T	4<W	4<W	4<W	
0+450		10<T	5<W	45<T	55<T	5<W	1<W	2<W	14<T	4<W	4<W	4<W	
0+590	0-10	20<T	35<T	25<T	45<T	5<W	1<W	2<W	58	4<W	4<W	4<W	
0+590	10-20	5<W	10<T	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+630-E		10<T	25<T	5<W	10<T	5<W	1<W	4<T	2<W	4<W	4<W	4<W	
0+710	0-10	70	5<W	10<T	80<T	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+710	10-20	5<W	5<W	40<T	40<T	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+710	20-30	40<T	20<T	5<W	40<T	5<W	1<W	10<T	2<W	24<T	4<W	4<W	
0+720-E		5<W	20<T	15<T	15<T	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+732	0-10	170	5<W	2200	2370	5<W	1<W	8<T	6<T	12<T	4<W	8<T	
0+732	20-30	5<W	35<T	30<T	30<T	5<W	2<T	12<T	2<W	32<T	4<W	4<W	
0+750	0-7	40<T	20<T	2100	2140	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+750	7-14	5<W	40<T	55	55	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+800		5<W	55	10<T	10<T	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
21S	0-10	20<T	35	260	280	5<W	1<W	2<W	2<W	20<T	4<W	20<T	
21S	10-20	15<T	50	85	100	5<W	1<W	2<W	2<W	16<T	4<W	4<W	

Table B-2: cont'd.

Station	Depth cm	PCB, total	Heptachlor	Aldrin	pp-DDE	Mirex	α-BHC	β-BHC	γ-BHC	α-Chlordane	γ-Chlordane	Oxychlordane
Bank samples												
0+310	0-10	20<W	1<W	1<W	110	5<W	1<W	16	16	2<W	2<W	2<W
0+310	10-24	600P40	1<W	1<W	590	5<W	1<W	1<W	10	4<T	2<W	2<W
0+397	0-10	20<W	1<W	1<W	10	5<W	1<W	17	3<T	2<W	2<W	2<W
0+397	10-20	20<W	1<W	1<W	14	5<W	1<W	26	1<W	2<W	2<W	2<W
0+397	20-30	20<W	1<W	1<W	13	5<W	1<W	11	1<W	2<W	2<W	2<W
0+450	0-10	20<W	1<W	1<W	12	5<W	1<W	16	3<T	2<W	2<W	2<W
0+450	10-20	20<W	1<W	1<W	22	5<W	1<W	16	1<W	2<W	2<W	2<W
0+565	0-12	20<W	1<W	1<W	63	5<W	3<T	4<T	12	2<W	2<W	2<W
0+565	12-24	20<W	1<W	1<W	1<W	5<W	1<W	28	47	2<W	2<W	2<W
0+630W		120P40	1<W	1<W	60	5<W	2<T	1<W	24	12<T	2<W	2<W
0+800	0-12	20<W	1<W	1<W	16	5<W	1<W	1<W	1<W	2<W	2<W	2<W
0+800	12-24	20<W	1<W	1<W	19	5<W	1<W	1<W	1<W	2<W	2<W	2<W

Station	Depth cm	op-DDT	pp-DDD	pp-DDT	op-DDT + pp-DDT	Methoxychlor	Heptachlor epoxide	Endosulphan-I	Dieldrin	Endrin	Endosulphan-II	Endosulphan sulphate	Octachloro-
Bank samples													
0+310	0-10	70	150	990	1060	5<W	1<W	2<W	4<T	4<W	4<W	4<W	
0+310	10-24	10<T	5<W	5<W	10<T	5<W	1<W	4<T	6<T	4<W	8<T	4<W	
0+397	0-10	5<W	10<T	5<W	5<W	5<W	1<W	2<W	10<T	4<W	4<W	4<W	
0+397	10-20	5<W	5<W	5<W	5<W	5<W	1<W	2<W	8<T	4<W	4<W	4<W	
0+397	20-30	5<W	35<T	5<W	5<W	5<W	1<W	2<W	6<T	4<W	4<W	4<W	
0+450	0-10	5<W	10<T	35<T	35<T	5<W	1<W	2<W	8<T	4<W	4<W	4<W	
0+450	10-20	5<W	5<W	5<W	5<W	5<W	1<W	2<W	8<T	4<W	4<W	4<W	
0+565	0-12	10<T	40<T	70	80	5<W	1<W	2<W	6<T	40	4<W	4<W	
0+565	12-24	10<T	20<T	10<T	20<T	5<W	1<W	2<W	100	8<T	4<W	4<W	
0+630W		200	5<W	2600	2800	5<W	1<W	14<T	2<W	4<W	24<T	4<W	
0+800	0-12	10<T	780	120	130	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
0+800	12-24	20<T	65	160	180	5<W	1<W	2<W	2<W	4<W	4<W	4<W	

Table B-3: Particle Size Distribution. Canagagigue Creek. 1995.

Station	Sand (>62 um) %	Silt (<62um, >2.63 um) %	Clay (<2.63 um) %
Stn 1	45	49	6.1
0+30	49	45	5.6
0+244	49	45	5.2
0+270	37	56	7.6
0+330C	50	45	4.9
0+320	50	46	4.7
0+330W	55	41	4.7
0+432	48	47	4.9
0+397	41	53	6.2
0+406	42	52	5.8
0+494	55	41	4.1
0+565	61	35	4.8
0+600	59	37	4.0
0+609 (0+630W)	40	52	8.3
0+732	61	35	3.9
0+738	32	61	6.8
0+750	50	44	5.9
0+785	51	45	4.7
Stn 20 0-15	67	29	4.2
Stn 20 15-30	32	59	9.1
Stn 21	52	42	5.4
Stn 22	46	49	5.0
Stn 23	43	52	5.6

Table B-4: Chlorophenol Concentrations in Sediment Samples. Canagagigue Creek. 1995
All concentrations in ng/g dry weight.

	2,3,4-Tri-chloro-phenol	2,3,4,5-Tetra-chloro-phenol	2,3,5,6-Tetra-chloro-phenol	2,4,5-Tri-chloro-phenol	2,4,6-Tri-chloro-phenol	Penta-chloro-phenol
Stn 1	10<W	10<W	5<W	20<W	10<W	5<W
0+30	10<W	10<W	5<W	20<W	10<W	5<W
0+244	10<W	10<W	5<W	20<W	10<W	5<W
0+270	10<W	10<W	5<W	20<W	10<W	5<W
0+330C	10<W	10<W	5<W	20<W	10<W	5<W
0+320	10<W	10<W	5<W	20<W	10<W	5<W
0+330W	10<W	10<W	5<W	20<W	10<W	5<W
0+432	10<W	10<W	5<W	20<W	10<W	5<W
0+397	10<W	10<W	5<W	20<W	10<W	5<W
0+406	10<W	10<W	5<W	20<W	10<W	5<W
0+494	10<W	10<W	5<W	20<W	10<W	5<W
0+565	10<W	10<W	5<W	20<W	10<W	5<W
0+600	10<W	10<W	5<W	20<W	10<W	5<W
0+630W*	10<W	10<W	5<W	20<W	10<W	5<W
0+732	10<W	10<W	5<W	20<W	10<W	5<W
0+738	10<W	10<W	5<W	20<W	10<W	5<W
0+750	10<W	10<W	5<W	20<W	10<W	5<W
0+785	10<W	10<W	5<W	20<W	10<W	5<W
Stn 20 0-15	10<W	10<W	5<W	20<W	10<W	5<W
Stn 20 15-30	10<W	10<W	5<W	20<W	10<W	5<W
Stn 21	10<W	10<W	5<W	20<W	10<W	5<W
Stn 22	10<W	10<W	5<W	20<W	10<W	5<W
Stn 23	10<W	10<W	5<W	20<W	10<W	5<W

<W = below detection limit

* stn 0+609 renamed to reflect actual distance

Table B-5: Chlorobenzene Concentrations in Sediment. Canagagigue Creek. 1995.
All concentrations in ng/g dry weight.

	Hexechloro butediene	123-tri-chloro-benzene	1234-tetra-chloro-benzene	1235-tetra-chloro-benzena	124-tri-chloro-benzene	1245-tatra-chloro-benzene	135-tri-chloro-benzene	Hexe-chloro-ethane	Penta-chloro-benzene	236-tri-chloro-toluene	245-tri-chloro-toluene	2,6-dichloro benzyl chloride
June 1995												
Stn 1	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+30	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+244	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+270	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+330C	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+320	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+330W	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+432	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+397	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+406	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+494	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+565	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+600	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+630W*	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+732	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+738	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+750	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+785	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
Stn 20 0-15	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
Stn 20 15-30	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
Stn 21	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
Stn 22	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
Stn 23	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
October1995												
0+30	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+285	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+456	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+565	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+590	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+609	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+668	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+732 0-12	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+732 12-25	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+750	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W
0+785	1<W	2<W	1<W	1<W	2<W	1<W	2<W	1<W	1<W	1<W	1<W	1<W

<W-below detection limit * stn 0+609 renamed to reflect actual distance

Table B-6: Sediment PAH Concentrations. Canagagigue Creek. July 1995

	Naphth-alene	Acenaph-thylene	Acenaph-thene	Fluorene	Phenan-threne	Anthra-cene	Fluoran-thene	Pyrene	Benzo[a] anthracene
Stn 1(C)	20<W	20<W	20<W	20<W	40<T	20<W	20<W	20<W	20<W
0+30 (C)	20<W	20<W	20<W	20<W	100	20<W	280	220	100
0+244	20<W	20<W	20<W	20<W	60<T	20<W	140	120	60<T
0+270	40<T	20<W	20<W	20<W	200	20<W	400	300	120
0+330C	20<W	20<W	20<W	20<W	80<T	20<W	200	140	60<T
0+320	20<W	20<W	20<W	20<W	240	20<W	420	300	120
0+330W	20<W	20<W	20<W	20<W	140	20<W	320	240	120
0+432	120	20<W	140	260	3200	440	3900	2600	1300
0+397	20<W	20<W	20<W	20<W	100	20<W	180	120	60<T
0+406	20<W	20<W	20<W	20<W	140	20<W	240	180	80<T
0+494	80<T	20<W	160	320	5100	660	7800	5300	2000
0+565	40<T	20<W	60<T	120	1600	140	3400	2400	1000
0+600	20<W	20<W	20<W	40<T	40<T	20<W	100	80<T	40<T
0+630W*	40<T	20<W	20<W	40<T	780	40<T	1500	1000	460
0+732	60<T	20<W	20<W	20<W	320	20<W	720	520	200
0+738	20<W	20<W	20<W	20<W	80<T	20<W	200	160	60<T
0+750	20<W	20<W	20<W	20<W	220	40<T	460	340	180
0+785	20<W	20<W	20<W	20<W	180	20<W	460	340	160
Stn 20 0-15	40<T	20<W	20<W	20<W	160	20<W	320	220	100
Stn 20 15-30	20<W	20<W	20<W	20<W	140	20<W	320	240	120
Stn 21	20<W	20<W	20<W	20<W	60<T	20<W	120	100	40<T
Stn 22	20<W	20<W	40<T	20<W	100	20<W	240	180	60<T
Stn 23	20<W	20<W	20<W	20<W	80<T	20<W	220	160	60<T

	Chrysene	Benzo[b] fluoran-thene	Benzo[k] fluoran-thene	Benzo[a] pyrene	Benzo [g,h,i] perylene	Dibenzo [a,h]an-thracene	Indeno [123-cd] pyrene	Total PAH
Stn 1(C)	20<W	20<W	20<W	40<W	40<W	40<W	40<W	420
0+30 (C)	120	120	80<T	80<T	80<T	40<W	80<T	1400
0+244	60<T	60<T	40<T	40<W	40<W	40<W	40<W	800
0+270	140	120	100	80<T	80<T	40<W	120<T	1820
0+330C	60<T	60<T	40<T	80<T	40<W	40<W	40<W	940
0+320	140	120	100	80<T	80<T	40<W	80<T	1820
0+330W	120	100	80<T	80<T	40<W	40<W	80<T	1460
0+432	1300	1100	840	920	600	120<T	720	17580
0+397	80<T	80<T	40<T	40<W	40<W	40<W	40<W	920
0+406	100	80<T	80<T	80<T	40<W	40<W	40<W	1200
0+494	2300	2000	1600	1700	1200	240	1400	31880
0+565	1300	1100	900	1000	720	120<T	880	14800
0+600	40<T	40<T	40<T	40<W	40<W	40<W	40<W	660
0+630W*	520	560	300	400	240	40<W	360	6320
0+732	240	260	160	200	160	40<W	200	3160
0+738	80<T	80<T	60<T	40<W	40<W	40<W	80<T	1020
0+750	220	180	140	160	120<T	40<W	120<T	2300
0+785	240	220	160	200	160<T	80<T	160<T	2460
Stn 20 0-15	100	100	80<T	80<T	40<W	40<W	80<T	1440
Stn 20 15-30	160	120	100	120<T	80<T	40<W	80<T	1620
Stn 21	80<T	60<T	40<T	40<W	40<W	40<W	40<W	760
Stn 22	120	120	80<T	80<T	80<T	40<W	80<T	1300
Stn 23	120	100	80<T	80<T	80<T	40<W	80<T	1200

<W = below detection limit <T = trace amount * stn 0+609 renamed to reflect actual distance

Table B-7: Metals and Nutrients in Surficial Sediments. Concentrations in ug/g dry weight unless otherwise noted.

	Al	As	Cd	Cr	Cu	Fe	Pb	Hg	Mn	Ni	Zn	TKN	TP
Stn 1	8100	1.6	0.2<W	13	8	12000	11	0.01<W	410	7.2	45	1000	560
0+30	8700	2.1	0.4<T	14	13	13000	22	0.01<W	440	9.2	77	1400	840
0+244	7300	2.4	0.2<W	15	19	11000	15	0.03<T	400	8	58	1200	640
0+270	7700	2.3	0.5<T	31	29	13000	17	0.07	510	62	70	1000	680
0+330C	8400	2	0.2<W	16	14	13000	10	0.01<W	490	9.4	69	1600	880
0+320	8500	2.1	0.4<T	14	14	13000	14	0.02<T	400	9	69	1700	840
0+330W	6800	1.6	0.4<T	12	13	11000	19	0.01<W	430	7.1	55	1500	840
0+432	4900	1.5	1.5	15	26	10000	45	0.08	300	7.1	110	1000	680
0+397	9200	2.2	0.4<T	16	17	14000	40	0.02<T	390	11	70	1700	700
0+406	9500	2.5	0.4<T	16	21	14000	18	0.03<T	530	10	77	1800	920
0+494	6900	2.5	0.4<T	20	72	13000	55	0.59	360	13	190	2600	1100
0+565	4400	1.3	0.4<T	11	26	8300	30	0.07	300	5.5	73	600	480
0+600	7300	2.6	0.2<W	13	11	14000	15	0.01<W	350	7.5	56	1400	720
0+630W*	5500	1.5	0.2<W	11	16	9500	14	7.2	360	6.5	59	800	660
0+732	5100	1.6	0.2<W	13	29	8700	20	0.13	300	8.1	75	1000	700
0+738	16000	3.4	0.6<T	24	25	22000	20	0.05	900	16	120	3300	1800
0+750	6200	1.9	0.5<T	13	34	11000	68	0.17	300	8.4	93	1100	620
0+785	11000	2.4	0.6<T	19	27	16000	26	0.06	590	12	97	1800	1200
Stn 20 0-15	4900	1.1	0.2<W	10	13	8800	13	0.04<T	310	5.6	53	800	520
Stn 20 15-30	6400	1.6	0.3<T	13	28	12000	27	0.14	370	8.2	83	1000	880
Stn 21	11000	2.3	0.6<T	18	19	16000	19	0.08	610	12	100	2500	1300
Stn 22	8000	1.9	0.3<T	13	14	12000	17	0.03<T	490	8.5	66	1100	780
Stn 23	12000	2.9	0.7<T	18	21	17000	22	0.05	770	12	110	3000	1400

Value = >SEL <W = delow detection limit <T = trace amount * stn 0+609 renamed to reflect actual distance

Tables

Table 1.1: Summary of Sediment and Benthic Sampling Locations
June 14 and 15 1995

Station	Location	Sample type	Sediment type	Parameters
Stn 1	Upstream control. Below bridge on Woolwich Rd 12 in agricultural area.	Surface Grab- Ekman-composite of 3 Benthos -Ekman 3 replicates	Fine grained sediments (silt) overlying sand and gravel	Nutrients & metals PCB/OC, PAH, Chlorobenzene Chlorophenol, dioxins.
0+30	Upstream control. At Uniroyal Property line below bridge on west side of Creek.	Surface grab-Ekman -composite of 3 Benthos- Ekman 3 replicates	Fine grained (silt) with fine to coarse detritus. Very soft sediment along w. bank of creek. Creek bottom gravel/sand & rock	As above
0+244	In pond on w. side, downriver from inflow (0-200) approx. 20 m from weir	Sediment core not obtained - material to loose. Surface grabs - composite of 3 Ekman samples Benthos - 3 Ekman replicates	Sand-silt sediment overlying sand & gravel.	as above
0+270	Downstream of weir on w. side in side-channel (at base of grey stairway on Uniroyal site) (corresp. to clam stn 4)	Sediment- surface grabs - composite of 3 Ekman samples. Benthos - Ekman (3 replicates)	Sandy sediments with pockets of fine-grained sediments along both sides. Samples collected from fine grained deposits along stream bank (gravel encountered at approx. 7 cm).	as above
0+330C	Middle channel approx. 20 m above culvert.	Sediment- surface grab - composite of 3 samples Benthos - 3 replicates (Ekman) taken at same location	Sandy main channel with back eddy areas of fine-grained sediment. Samples collected in back eddy closest to confluence of three channels (on w. side of channel).	as above
0+320	Above culvert in east channel (in same line as stn 0+330C).	Sediment- surface grab-composite of 3 samples Benthos - 3 replicates (Ekman) taken at same location.	Sediments same as stn 0+330C. First back eddy bay upstream from confluence sampled.	as above
0+330W	In west channel above confluence of w., middle, and e. side channels above culvert. Main flow channel.	Sediment -surface grab-composite of 3 samples. Benthos - 3 replicates (Ekman) taken at same location.	Main channel hard (gravel/sand/ cobble) substrate. Back eddy pools along side with accumulations of fine sediments. Deep soft sediments in pools sampled.	as above
0+432	Shirt Factory Creek - approx. halfway down the creek. (nr. SS15A)	Sediment - surficial grab from fine-sediment deposits along bank. Benthos- samples from adjacent riffle (cobble/gravel) substrates (3 Surbers)	Small channel on west side, approx. halfway along channel. Mainly cobble/gravel substrate with pockets of fine-grained sediments deposited along the bank.	as above

Stetion	Location	Sample type	Sediment type	Parameters
0+397	East side of creek opposite Shirt Factory Creek approx. 50 m below culvert. Sampled in small embayment.	Sediment -surface greb - composite of 3 Ekman samples Benthos - sampled in adjacent riffle section - 3 Surbers.	Creek flows over wide riffle section in this area (rock/gravel/ cobble substrate). Small back eddy pool ~1m across, on east side with accumulation of fine-grained sediments (brown-grey sediments conteining coarse organic dabris)	as above
0+406	West side of creek opposite stn 0+397. In small embayment/ back eddy.	Sediment - surface grab - composite of 3 Ekman samples. Benthos - 3 replicate grabs (Ekmen).	Creek as described for stn 0+397. Back eddy pool on west side approx. 45-50 m below culvert. Soft fine-grained sediments (light brown surficial layer overlying grey deeper layer). Some fine detritus.	as above
0+494	Seep area below Shirt Factory Creek on west side. Adjacent to gravel bar island (1st large one below Shirt Factory Creek).	Bank cora not taken - refusal occurred at 10-15 cm. Sediment- surficial grab - composite of 3 Ekman samples Benthos - 3 replicates (Ekman)	Small west channel (very little flow) extending down from Shirt Factory Creek. Gravel/cobble substrate in channel with pockets of fine sediment and sand along banks. Fine silt and detritus in samples.	as above
0+565	Downstream of Shirt Factory Creek in west channel (clam stn 8) just at division of w. channel into seep area.	Sediment - surficial grab - composite of 3 Ekman grabs Benthos - 3 replicate Ekman grabs	Small channel, loose sand and gravel substrate. Surface layer normal colour, but ca. 1-2 cm below, black sand and gravel. Fine sediment and sand deposits along sides of channel. Black layar under flocculent light brown surface layer. Banthic samples from weedy area.	as above
0+600	East bank in backwater, opposite stn 0+565 at 0+600 marker. In embayment where creek swings to the west.	Sediment- surface grab- composite of 3 Ekman grabs Benthos - 3 replicate Ekman grabs	Creek fast flowing with rock/cobble bottom. Backwater embayment underlaid with rock & gravel. Fine sediments accumulated near head of bay. Very soft sediments of sand silt and gravel. Normal colour at surface, below 2-3 cm stained black.	as above
0+609	West channel, downstream of station 0+565 (actual distance is 630m). Exposed bank with pools of discoloured water.	Bank core not obtained - refusal at <10 cm (gravel). Bank samples teken (surficial)	Black stained sand and silt. Visible sheen and pools of discoloured water. Very strong odour.	as above + EXT 3186 and ID3197

Station	Location	Sample type	Sediment type	Parameters
0+732	South end of west channel (i.e. approx. 15 upstream) near east bank of channel (just below clam stn 9)	Sediment- surficial greb - composite of 3 Ekman grabs Benthos- 3 replicata Ekman samples.	West side of channel tiled. Central section sand/gravel with depositional areas of fine-grained sediment on east side. Light brown surface layer over black layer. Gravel at 15 cm depth.	as stn 1
0+738	Same as station 0+732, but east bank (clam stn 10). Upstream of confluence of west and main channels. In small embayment.	Sediment- surficial grab- composite of 3 Ekman grabs Benthos - both Ekman samples in embayment and riffle samples in adjoining riffle. 3 replicates each	Small embayment on west side of east channel. Soft sediments along bank. Light brown surface layer over grey coloured mud/sand. Stream fast flowing, gravel/ rock/cobble substrate (surber).	as above
0+785	Below confluence of west and east channels, just up from STP (clam stn 11) outfall.	Sediment - surface grab - composite of 3 Ekman grabs Benthos - surber samples in adjacent riffle. 3 replicates	Pocket of fine sediment on west side of channel in small back eddy just up from STP outfall. Ca. 15 cm of fine seds. and sand overlying loose unconsolidated gravel. Light brown surface sediment overlying grey deeper layers.	as above
0+750	South end of long bar at confluence of west and main channels. Large back eddy pool.	Sediment- surficial grab - composite of 3 Ekman grabs. Cores attempted- material to unconsolidated and loose to obtain core. Benthos - 3 replicate Ekman grabs.	Back eddy pool. Fine sediments and sand overlying loose unconsolidated gravel (very soft, shifting gravel). Surface layers light brown. Deeper layer black with organic detritus. Strong odour.	as above
20	Below STP, past bend on east side, downstream of small exposed bar deposit (just upstream from clam stn 12. On east bank in back eddy pool.	Sediment - core samples to 40 cm. -composite of 4 cores (3 cores to 30 cm, 1 core to 40 cm) sectioned into 0-15 cm and 15-30 cm. Benthos - 3 replicate Ekman samples	Surface layers light brown fine material. Light brown - grey layer to 15 cm. Black stained layer below 15 cm. High sand content in lower layers.	as above
21	At 1st bridge below STP. Under bridge on s side next to bridge footings.	Sediment- surficial grab - composite of 3 replicate grabs Benthos - 3 replicate Ekman grabs	Soft sediments consisting mainly of fine silt with some sand and fine organic detritus. Light brown surface layer and grey-black deeper layers. Creek comprised of rock/gravel/cobble substrate.	as above

Station	Location	Sample type	Sediment type	Parameters
22	At 2nd bridge below STP. Downstream of bridge beside cow pasture in back eddy pool.	Sediment - surficial grab - composite of 3 Ekman grabs. Benthos- 3 replicate Ekman grabs	Soft fine grained sediments in pool overlying deeper unconsolidated sand/gravel layers. Light brown surface layers overlying grey deeper layers. Some sand (1 sample) and fine organic detritus (2 samples).	as above
23	At 3rd bridge below STP. Downstream from bridge on n. side in embayment ca. 20 m from bridge.	Sediment - surficial grab - composite of 3 Ekman samples. Benthos - 3 replicate Ekman grabs.	Fine silt and organic detritus overlying sand and gravel. Light brown surface layers with grey deeper layers.	as above

Table 1.2: Summary of Sediment Sampling Locations.
October 1995

Station	Location	Sample type	Sediment type	Parameters
0+30	Upstream control. At Uniroyal Property Line below bridge, w. bank of creek.	Hand sampled (shovel) to approx. 20 cm depth. Sample integrated over depth of sample	Variable. Ranged from soft, fine-grained material to sand/gravel.	PCB/OC DIOX
0+285	Downstream of weir on w. side of creek in side channel, at downstream end of side channel.	Hand sampled (shovel) to approx. 15 cm depth close to bank on w. side. Sample integrated over depth of sample.	Mainly sand and gravel with some fine-grained (silt) material.	PCB/OC DIOX
0+456	Downstream of Shirt Factory Creek approx. midway between stn 0+432 and stn 0+494 (June 1995)	Hand sampled (shovel) to approx. 15 cm depth (sample integrated over depth).	Mainly sand and gravel with small amount of fine-grained material. Strong solvent smell in area.	PCB/OC DIOX
0+590	East bank in backwater at 0+600 marker. In centre of embayment in sand/gravel area.	Hand sampled (shovel) to approx. 15 cm depth.	Black discoloured sand/gravel overlain by thin layer of fine-grained (silt) material.	PCB/OC DIOX
0+609	West channel along exposed bank.	Hand sampled (shovel) to approx. 20 cm depth (sample integrated over depth of sample).	Black discoloured sand/gravel with strong odour (benzothiazole?) overlain by surface layer (ca, 1 cm) of light coloured sand.	PCB/OC DIOX
0+668	West channel approx. midway between station 14 and stn 15 in small side trickle.	Hand sampled (shovel) to approx. 15 cm depth (sample integrated over depth of sample).	Black discoloured sand/gravel/rock with strong chemical smell. Creek bottom discoloured with white precipitate.	PCB/OC DIOX

Station	Location	Sample type	Sediment type	Parameters
0+732	West channel at downstream end (approx. 15m from confluence).	Hand sampled (shovel) to 25 cm depth. Sample divided into 0-5" (0-12cm) and 5-10" (12-25cm) sections.	Black discoloured sand and gravel.	PCB/OC DIOX
0+750	At downstream end of west channel in large embayment.	Hand sampled (corer) to 10 cm depth.	Black discoloured sand and gravel with strong chemical smell.	PCB/OC DIOX
0+785	In main channel just upstream from STP outfall.	Hand sampled (shovel) to 10 cm depth.	Sand and gravel with some fine-grained material (no discolouration or odour)	PCB/OC DIOX

Table 1.3: Summary of Sediment Sampling Locations.
November 1995.

Station	Location	Sample Type	Sediment Type	Parameters
0+120	At upper end of pond behind weir, on east side	Cores - 2 sections: 0-8 cm; 8-20 cm	Soft fine grained (silt) sediments overlying sand & gravel	PCB/OC DIOX
0+438	Shirt Factory Creek, below outfall ca. 20m in channel.	Hand sampled (shovel) to ca. 5" depth.	Layer of silty sediment overlying sand and gravel.	as above
0+468	Shirt Factory Creek just above entrance to plant site.	Hand sampled (shovel) to ca. 5" depth.	Silty sand and gravel beside culvert.	as above
Stn 21 Pond	Approx. 100m upstream from road. Old cutoff pond beside creek.	Hand sampled (shovel) to 25 cm depth.	Black organic detritus.	as above
Stn 21 Stream	Approx. 100m upstream from road. Sand/gravel bar in creek.	Hand sampled (shovel) to 10 cm depth	Fine silty sediments overlying sand and gravel.	as above

Table 2.1. Summary of Sediment and Biological Sampling Locations
May 28 - 30, 1996

Station	Location	Sample Type	Chemical Tests	Description	Biological Tests
0+30	On west side below upper property line (Rd. 86). On west side of creek in depositional area of very soft sediments	Sediment cores: 3 replicates: 40 cm 42 cm 50 cm. 4 sections - 0-10; 10-20; 20-30; 30-40 cm	TOC PCB/oc Diox	Sandy silt overlying deeper clay layers (light grey).	Sed. bioassay Benthic community-sampled in 1995

Station	Location	Sample Type	Chemical Tests	Description	Biological Tests
0+240	In impoundment above dam, along east side.	Sediment cores: 3 replicates: 20 cm 19 cm 24 cm 2 sections - 0-10; 10-20 cm	TOC PCB/oc Diox	Light brown surface layer, primarily silt. Grey-black sand middle layer; clay layer at bottom.	Benthic community
0+244	In impoundment above dam, along west side.	Sediment cores: 3 replicates: 18 cm 19 cm 18 cm 2 sections - 0-8 cm; 8-18 cm	TOC PCB/oc Diox	Top layer of fine loose silt. Clay-silt mixture in middle. Clay and sand at bottom.	Benthic community - sampled in 1995 Sed. bioassay
0+310	Along west side below confluence of small side channel. At base of grey stairway. Sample collected from exposed bank.	Sediment cores: None - hard substrate. Bank cores: 3 replicates: 24 cm 24 cm 22 cm 2 sections: 0-10 cm; 10-24 cm	TOC PCB/oc Diox	Silty sand with organic detritus in bottom layers. No surface vegetation (area inundated during high water)	None
0+360	Along east side just above bridge. Large backeddy pool, very soft substrate.	Sediment cores: 3 replicates: 24 cm 22 cm 25 cm	TOC PCB/oc Diox	Light brown silt layer on surface intermixed with sand. Sand and clay in deeper layers.	Benthic community
0+345	Along west side. At downstream end of small west channel just above confluence with main channel.	Sediment cores: None (gravel substrate) Sediment grabs: 3 replicates (1 composite).	TOC PCB/oc Diox	Light brown surface silt (some sand) <1 cm. overlying black anoxic deeper layers.	Benthic community
0+397	East side below bridge. Small embayment area adjacent to wide riffle area.	Sediment cores: None - <5 cm silt and sand over gravel. Sediment grabs: 3 replicates (1 composite) Bank cores: 3 replicates - 30 cm 3 sections; 0-10; 10-20; 20-30 cm	TOC PCB/oc Diox	Sediment: light brown silt over gravel. Soil: brown-grey cohesive soil. Clay at bottom.	Benthic community - sampled in 1995 Sed. bioassay - not enough sediment.
0+450	Along east side opposite Shirt Factory Creek. At marker.	Sediment cores: None - <5 cm silt overlying gravel. Bank cores: 3 replicates; 20 cm 2 sections; 0-10; 10-20 cm	TOC PCB/oc Diox	Sediment: light brown silt (~5 cm) over gravel. Bank: silt/sand, matted vegetation. Clay layer on bottom.	Benthic community
0+565	At top end of west channel in primary seep area. Exposed bank adjacent to creek.	Sediment cores: None - <5 cm silt overlying gravel. Bank cores: 3 replicates; 24 cm 2 sections; 0-10; 10-24 cm	TOC PCB/oc Diox	Thin light brown sand & silt surface layer. Black (oily) silt and sand overlying gravel. No surface vegetation (inundated during high water).	Benthic community - sampled in 1995

Station	Location	Sample Type	Chemical Tests	Description	Biological Tests
0 + 590	East side of creek in alrge embayment. At upstream end of embayment.	Bank cores: 3 replicates; 20 cm 2 sections; 0-10; 10-20 cm	TOC PCB/oc Diox	Light brown surface layer over black (anoxic) deeper layer containing organic detritus.	None
0 + 630 W (0 + 609)	West chennel, approx 50 -60 m from upstream end. Exposed low benk. Station renamed 0 + 630W to reflect actual distance.	Sediment cores: None - <5 cm soft sediment over gravel Benk cores: None Bank surface sample: composite of 3.	TOC PCB/oc Diox	Thin layer (~ 1cm) light brown sand and silt over black (oily) sand. Gravel underneath. Strong odour. No vegetation - area periodically inundated.	Sed. bioassay
0 + 630E	Along east side. Directly across from main seep area.	Sediment cores: None - <5 cm fine sediment over gravel Sediment grabs: 3 replicates (to 8 cm depth)	TOC PCB/oc Diox	Thin light brown layer of silt and sand on surface. Black oily sediment underneath.	Benthic community
0 + 720E	Along east side opposite fence line. Small visible seeps of liquid along bank.	Sediment grabs: 3 replicates (to 6 cm depth)	TOC PCB/oc Diox	Light brown silt and sand layer (~ 2.5 cm) overlying gravel. Surface seeps of oily material.	Benthic community
0 + 732	In west channel, near downstream and. Sediment cores obtained in small embayment.	Sediment cores: 3 replicates; 30 cm 40 cm 37 cm 2 sections; 0-10; 20-30	TOC PCB/oc Diox	Light brown surface layer of silty sand overlying deeper layer of clay. Clay strongly discoloured (black) with strong chemical odour.	Benthic community - sampled in 1995
0 + 710	Small pool area in west channel at in-stream marker.	Sediment cores: 3 replicates; 30 cm 30 cm 37 cm 3 sections; 0-10; 10-20; 20-30 cm. (single section 30-37 retained for dioxin analysis)	TOC PCB/oc Diox	Thin layer of light brown silt over sand/clay layer. Strongly discoloured, very strong odour esp. in deeper layers.	None
0 + 750	Backeddy at downstream end of west channel.	Sediment cores: 3 replicates - 14 cm 2 sections; 0-7; 7-14 cm	TOC PCB/oc Diox.	Light brown silt and sand layer (very soft and loose) overlying loose unconsolidated gravel. Large amount of organic detritus. Strong chemical odour.	Benthic community (also sampled in 1995) Sed. bioassay

Station	Location	Sample Type	Chemical Tests	Description	Biological Tests
0+800	On east side of creek opposite STP outfall. Behind large gravel bar in depositional area	Sediment cores: None - <5 cm fine sediment over gravel. Surficial grab sample. Bank cores: (hand - shovel) 3 replicates; 24 cm 2 sections; 0-12; 12-24 cm	TOC PCB/oc Diox	Sediment: Light brown sand and gravel. Soil: light brown silt and sand layer. Deeper layers mainly sand and gravel	Benthic community
Stn 21-S	East side of stream, approx. 100m upstream of 1st bridge below site. Protected area behind sand/gravel bar.	Sediment cores: 3 replicates; 20 cm 2 sections; 0-10; 10-20 cm	TOC PCB/oc Diox	Sand with some silt. Uniform colour and texture throughout.	Benthic community Sed. bioassay

Table 2.2. Summary of Sediment and Biological Sampling
Sept. 30 - Oct 1, 1996

Station	Location	Sample Type	Chemical Tests	Biological Tests
Sediment cores and/or grabs:				
127-S	Bank of stream at 127-S well location. Approx. midway between station 0+310 and 0+345.	Bank cores: 2 sections: 0-10 and 10-20 cm.	TOC PCB/oc Diox	None
Above 127-S	Bank of stream above 127-S well.	Not sampled: corresponds to Stn 0+310, sampled in May-June.		
Biological sampling				
0+30	At north property line below Rd. 86	Benthic tissue residue analysis: ~ 10 gms dragonfly larvae.	Diox	Tissue residue for Dioxins
127-S	See above	Benthic tissue residue attempted. No sample obtained.		
0+565	West channel at south end of property. Upstream end.	Benthic tissue residue; ~ 12 gms dragonfly larvae.	Diox	Tissue residue for Dioxins
0+750	Downstream end of west channel.	Benthic tissue residue; ~ 12 gms dragonfly larvae.	Diox	Tissue residue for Dioxins
FP-3	Pond on floodplain at 1st downstream bridge	Benthic - tissue residue. No sample - insufficient organism biomass. Limited benthic diversity suggests this is a temporary pool that dries up in summer.		

Table 3. Summary of Floodplain Sampling

Station	Date	Location	Sample Type	Parameters	Description
FP-C1	Oct 1 1996	Floodplain control. Wetland below Woolwich Rd 12 just above bend in river. On west side. (Map Ref. 10 17 53539 482883)	Sediment cores: 1 section only; 0-10 cm (to refusal)	TOC PCB/oc Diox	Low bank area, partially submerged vegetation. Sand/silt with roots.
FP-C2	Oct 1 1996	Floodplain control. Below Floradale dam on east side. (Map Ref. 10 17 53554 482939)	Sediment cores: 1 section only: 0-10 cm (to refusal)	TOC PCB/oc Diox	Low bank area, partially submerged vegetation. Sand-silt over gravel.
FP-1	May 30 1996	Approx. 1 km downstream of Uniroyal property just downstream of farm bridge. (Map Ref. 10 17 53664 48261)	Sediment cores: 3 replicates; 30 cm each (approx. 10 cm compression) 2 sections; -12; 12-24 cm	TOC PCB/oc Diox	Exposed bank area. Very soft silty sediments overlying black, anoxic sediments high in organic detritus. Approx. 10 cm compression in each core
FP-2	May 30 1996	Approx. midway between FP-1 and FP-3. Exposed area on west side (Map Ref. 10 17 53701 482576)	Sediment cores: 3 replicates; 30 cm 30 cm 28 cm approx. 10 cm compression in each 2 sections; 0-12; 12-24 cm	TOC PCB/oc Diox	Exposed bank area. Very soft silty sediments over grey-black organic/sand layer. Approx. 10 cm compression in each core.
FP-3	May 30 1996	Old station 21-p. Approx. 100m upstream of 1st bridge (Map Ref. 10 17 53745 482570)	Sediment cores: 3 replicates; 37 cm 20 cm 24 cm 2 sections; 0-10; 10-20 cm	TOC PCB/oc Diox	Forest pond. Fine silt layer over black organic detritus. Clay layer ~35 cm down.
FP-4	May 14 1996	Below 1st bridge, in wooded area below grazing pasture, approx. 30m from creek. (Map Ref. 10 17 53809 482594)	Sediment cores: None - <5 cm fine sediment over gravel Sediment grab; shovel to 14 cm depth (integrated)	TOC PCB/oc Diox	Temporary forest pond. Brown cohesive soil.
FP-5	May 14 1996	Approx. midway between 1st and 2nd bridge on west side. Stagnant pool in wooded area. (Map Ref. 10 17 53888 482541)	Sediment cores: None-dense organic mat restricted core. Sediment grab: shovel to ~8 cm depth.	TOC PCB/oc Diox	Stagnant pond overgrown with duckweed. Dense mat of organic debris below surface. Strong H2S odour.
FP-6	May 14 1996	Approx. 0.5 km upstream of Rd. 22 on east side at edge of grazing area. (Map Ref. 10 17 53940 482500)	Sediment cores: None - <5 cm fine sediment over gravel and rock Sediment grab: shovel to 8 cm depth	TOC PCB/oc Diox	Small pond at grazing area/forest border. Silty soil (~5 cm) overlying gravel and rock.
FP-7	May 14 1996	Downstream of Regional Rd 22. Pond at edge of grazing pasture. (Map Ref. 10 17 53989 482501).	Sediment cores: None- <5 cm fine sediment over rock and gravel Sediment grab: shovel to 14 cm	TOC PCB/oc Diox	Pond in farm field/grazing land. Silt and organic detritus in surface layer (black in colour) Clay layer underneath.

FP-8	May 14 1996	Approx. midway between 2nd and 3 rd bridge (Map Ref. 10 17 54035 482504)	Sediment cores: 3 replicates: 30 cm 2 sections; 0-10; 10-30	TOC PCB/oc Diox	Dry forest pond approx. 10m from creek. Brown cohesive soil.
FP-9	May 14 1996	Approx. 0.5 km upstream of 3rd bridge on west side. In wet depression approx. 5 m from creek. (Map Ref. 10 17 54049 482473).	Sediment cores: 3 replicates; 20; 17; 17 2 sections: 0-10; 10-20	TOC PCB/oc Diox	Very small woodland pond ~5m from creek. Light brown surface layers grading to grey (clay) underneath. Very firm
FP-10	May 14 1996	Approx. midwey between 3rd bridge and mouth (Map Ref. 10 17 54106 482431)	Sediment core: None Sediment grab: shovel to 30 cm depth	TOC PCB/oc Diox	Old river meander next to field. Silt and organic detritus overlying clay.
Soil Samples					
FP-3	Oct 1 1996	Old station 21-p. Approx. 100m upstream of 1st bridge (Map Ref. 10 17 53745 482570)	Soils around pond approx. 2m from waters edge. Core samples to 20 cm. 2 sections: 0-10 cm; 10-20 cm	TOC PCB/oc Diox	Light brown soil. No visible horizon to 20 cm.
Water Samples					
FP-3	Oct 1 1996	As above	Water in pond. 2 samples: undisturbed water sample; disturbed water sample	Diox	
FP-7	Oct 1 1996	Downstream of Regionel Rd 22. (Map Ref. 10 17 53989 482501).	Water in pond. 2 samples: undisturbed water sample; disturbed water sample.	Diox	

Table 4: DDT and Metabolites in Sediment. Canagagigue Creek 1995-1996.
All values in ng/g dry weight unless otherwise indicated.

Station	Depth	Location	Date	pp-DDE	pp-DDD	op-DDT	pp-DDT	Total DDT (op + ppDDT)	TOC mg/g
Stn 1	Surface		1995/06	1 < W	5 < W	5 < W	5 < W	5 < W	11
0+30	Surface	West	1995/06	5 < T	5 < W	5 < W	5 < W	5 < W	19
0+30	Surface		1995/10	5 < T	5 < W	5 < W	5 < W	5 < W	
0+30	0-10 cm		1996/05	2 < T	5 < W	5 < W	5 < W	5 < W	
0+30	10-20 cm		1996/05	3 < T	5 < W	5 < W	5 < W	5 < W	
0+30	20-30 cm		1996/05	2 < T	5 < W	5 < W	5 < W	5 < W	
0+30	30-40 cm		1996/05	4 < T	5 < W	5 < W	5 < W	5 < W	
0+120	0-8 cm	East	1995/11	8	5 < W	5 < W	5 < W	5 < W	31
0+120	8-20 cm		1995/11	10	5 < W	5 < W	5 < W	5 < W	22
0+240E	0-10 cm	East	1996/05	3 < T	5 < W	5 < W	5 < W	5 < W	
0+240E	10-20 cm		1996/05	4 < T	5 < W	5 < W	5 < W	5 < W	
0+244	Surface	West	1995/06	120	100	5 < W	2800	2800	12
0+244	0-8 cm		1996/05	8 < T	10 < T	5 < W	40 < T	45	
0+244	8-18 cm		1996/05	49	120	15 < T	160	175	
0+270	Surface	West	1995/06	340	370	280	4000	4280	15
0+285	Surface	West	1995/10	180	220	45 < T	340	385	
0+330C	Surface	Centre	1995/06	11	45	5 < W	50	50	19
0+320	Surface	East	1995/06	6	45	25	45 < T	70	22
0+330W	Surface	West	1995/06	24	80	200	220	420	17
0+345	Surface	West	1996/05	64	90	20 < T	130	150	
0+360E	0-10 cm	East	1996/05	20	50	35 < T	5 < W	40	
0+360E	10-24 cm		1996/05	760	25 < T	2800	9500	12300	
0+397	Surface	East	1995/06	28	120	55	120	175	21
0+397	Surface		1996/05	7 < T	15 < T	5 < W	5 < W	5 < W	
0+406	Surface	West	1995/06	30	60	65	250	315	20
0+432	Surface	SFC	1995/06	32	120	60	120	180	17
0+438	0-10 cm	SFC	1995/11	1 < W	45	5 < W	5 < W	5 < W	36
0+450	Surface	East	1996/05	5 < T	5 < W	10 < T	45 < T	55	
0+456	Surface	SFC	1995/10	75	24	60	300	360	
0+468	0-10 cm	SFC	1995/11	12	5 < W	5 < W	5 < W	5 < W	35
0+494	Surface	West	1995/06	50	270	5 < W	200	200	47
0+494	Surface		1995/10	46	190	10 < T	60	70	
0+565	Surface	West	1995/06	37	60	5 < W	180	180	11

SFC = Shirt Factory Creek

Table 4: cont'd

Station	Depth	Location	Date	pp-DDE	pp-DDD	op-DDT	pp-DDT	Total DDT (op+pp-DDT)	TOC mg/g
0+590	Surface	East	1995/10	19	150	15<T	50	65	
0+600	Surface	East	1995/06	11	25	5<W	85	85	8.4
0+630W	Surface	West	1995/06	42	420	5<W	1700	1700	12
0+630W	Surface		1995/10	160	480	150	1100	1250	
0+630W	Surface		1996/05	60	5<W	200	2600	2800	
0+630E	Surface	East	1996/05	8<T	25<T	10<T	5<W	10<T	
0+668	Surface	West	1995/10	92	500	60	180	240	
0+710	0-10 cm	West	1996/05	400	5<W	70	10<T	80	
0+710	10-20 cm		1996/05	670	5<W	5<W	40<T	40<T	
0+710	20-30 cm		1996/05	1<W	20<T	40<T	5<W	40<T	
0+720E	Surface	East	1996/05	8<T	20<T	5<W	15<T	15<T	
0+732	Surface	West	1995/06	69	220	75	440	515	12
0+732	0-5 cm		1995/10	50	210	30	300	330	
0+732	5-10 cm		1995/10	1100	5800	660	2300	2960	
0+732	0-10 cm		1996/05	160	5<W	170	2200	2370	
0+732	20-30 cm		1996/05	520	35<T	5<W	30<T	30<T	
0+738	Surface	East	1995/06	13	20<T	5<W	30<T	30<T	33
0+750	Surface	West	1995/06	87	180	50	370	420	22
0+750	Surface		1995/10	110	260	50	150	200	
0+750	0-7 cm		1996/05	100	20<T	40<T	2100	2140	
0+750	7-14 cm		1996/05	59	40<T	5<W	55	55	
0+785	Surface	Centre	1995/06	75	200	65	1200	1265	35
0+785	Surface		1995/10	35	120	25<T	130	155	
0+800	Surface	East	1996/05	15	55	5<W	10<T	10<T	
Stn 20	0-15 cm		1995/06	36	150	45	1400	1445	13
Stn 20	15-30 cm		1995/06	120	380	5<W	500	500	14
Stn 21	Surface		1995/06	40	50	15<T	45	60	28
Stn 21S	0-10 cm		1996/05	52	35	20<T	260	280	
Stn 21S	10-20 cm		1996/05	89	50	15<T	85	100	
Stn 22	Surface		1995/06	45	65	25<T	360	385	16
Stn 23	Surface		1995/06	34	40	5<W	75	75	49

Table 5: Sediment Dioxin and Furan Concentrations. Canagagigue Creek 1995-96. (All values in pg/g (ppt)). Concentrations listed are totals for each congener group.

Station	Depth (cm)	*	Date	T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
Stn 1			1995/06	2.4	I1	1	<	1	<	1	<	1	<	1.9	I2	2	<	7.3	I2	2.4	20
0+30		W	1995/06	2	<	1.5	I1	6.3	I2	1	<	7.1	I3	6.1	I3	13	I2	32	I2	11	110
0+30			1995/10	7.8	I6	1.6	I1	6.7	I2	1	<	6.8	I4	5.9	I3	11	I2	22	I2	13	79
0+30	0 -10		1996/05	7.9	I5	4.3	I2	8.8	I3	1	<	9.4	I3	9.7	I5	26	I2	43	I2	26	150
0+30	10-20		1996/05	31	I17	4.5	I2	25	I9	1.4	I1	26	I7	15	I6	34	I4	65	I2	45	190
0+120	0 -8	E	1995/11	16	I7	32	I3	23	I3	6.1	I2	21	I5	16	I4	26	I2	53	I2	27	170
0+120	8 -20		1995/11	17	I6	36	I3	41	I3	6.3	I2	28	I5	20	I5	18	I2	39	I2	17	110
0+240E	0 -10	E	1996/05	7.5	I2	3.3	I2	9.7	I2	2.7	I2	4.2	I2	7.3	I3	12	I2	37	I2	10	130
0+240E	10-20	E	1996/05	11	I1	6.7	I3	17	I2	2.8	I2	5.8	I3	6.1	I3	15	I2	26	I2	14	83
0+244		W	1995/06	7.8	I4	6.2	I3	10	I3	1.1	I1	16	I4	6.4	I3	53	I2	37	I2	48	110
0+270		W	1995/06	23	I5	17	I4	19	I3	4.3	I2	52	I6	37	I4	120	I3	130	I2	130	2200
0+285		W	1995/10	5.6	I4	3.3	I2	6.1	I3	1	<	7.5	I3	4.7	I2	22	I2	20	I2	25	67
0+330C		C	1995/06	7.8	I1	2.3	I1	5.7	I2	1	<	4.1	I2	2.9	I1	13	I2	37	I2	13	88
0+320		E	1995/06	38	I3	9.4	I2	7.9	I2	1	<	5.3	I2	3.4	I1	18	I2	45	I2	18	110
0+330W		W	1995/06	17	I2	3.8	I1	5.7	I2	1	<	7.3	I2	1.9	I1	17	I2	24	I2	20	87
0+345		W	1996/05	9.4	I3	4.3	I2	12	I3	2	<	21	I3	18	I5	150	I2	110	I2	270	480
0+360	0 -10	E	1996/05	160	I6	43	I4	43	I3	2.1	I1	21	I3	13	I4	81	I2	170	I2	79	1600
0+360	10-20		1996/05	180	I7	47	I4	43	I3	3	I2	20	I3	8.2	I3	74	I2	46	I2	73	150
0+397		E	1995/06	280	I6	85	I3	87	I3	15	I5	51	I5	5.8	I2	170	I2	64	I2	230	220
0+397	Surface		1996/05	92	I6	33	I4	37	I6	6.4	I4	22	I6	6.5	I4	72	I2	24	I2	88	89
0+406		W	1995/06	120	I9	37	I4	36	I3	3.9	I3	30	I5	17	I5	88	I2	97	I2	100	520

I - Total number of isomers < - Below detection limit

* - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel

Table 5: cont'd.

Station	Depth (cm)	*	Date	T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
0+432		SF	1995/06	34	I6	7	I3	44	I4	1.9	I1	48	I6	23	I3	73	I2	110	I2	87	430
0+438		SF	1995/11	23	I5	20	I3	33	I4	9.4	I2	28	I3	27	I5	57	I2	110	I2	64	710
0+468		SF	1995/11	15	I5	3.8	I2	63	I7	2.8	I1	71	I6	48	I5	96	I3	230	I2	120	1200
0+456		SF	1995/10	59	I6	13	I4	35	I5	1.9	I1	32	I5	20	I5	69	I3	74	I2	88	270
0+450	Surface	E	1996/05	180	I11	42	I4	39	I3	7.0	I3	22	I3	13	I5	79	I2	42	I2	90	150
0+494		W	1995/06	85	I7	25	I4	80	I6	6.3	I3	110	I6	55	I6	370	I3	230	I2	470	950
0+565		W	1995/06	89	I7	26	I4	39	I4	1.8	I1	40	I6	18	I5	98	I2	66	I2	120	250
0+600		E	1995/06	86	I6	25	I4	23	I3	2	<	14	I3	3.3	I1	42	I2	31	I2	50	110
0+590		E	1995/10	160	I6	47	I4	45	I3	5.7	I3	24	I3	8.1	I4	60	I2	22	I2	84	77
0+630W		W	1995/06	120	I8	27	I4	38	I4	3.2	I2	31	I5	14	I4	74	I2	54	I2	76	170
0+630W		W	1995/10	380	I6	87	I5	110	I6	12	I5	80	I6	23	I5	400	I4	68	I2	600	220
0+630W	Surface	W	1996/05	1400	I11	44	I6	260	I7	16	I3	140	I8	23	I5	300	I3	100	I2	100	280
0+630E	Surface	E	1996/05	110	I6	24	I4	23	I3	6.6	I3	10	I3	11	I3	35	I2	27	I2	41	85
0+668		W	1995/10	220	I10	54	I4	52	I4	8	I4	41	I5	22	I5	130	I4	62	I2	150	180
0+710	0 -10	W	1996/05	780	I13	140	I6	350	I8	40	I7	290	I8	80	I6	530	I3	130	I2	640	430
0+710	10-20		1996/05	1300	I14	240	I6	570	I9	67	I7	440	I8	91	I6	1200	I3	180	I2	1400	550
0+710	20-30		1996/05	2000	I10	390	I4	1200	I7	110	I8	620	I7	98	I6	1400	I3	150	I2	1300	430
0+710	30-37		1996/05	220	I12	260	I9	180	I7	88	I7	240	I7	83	I6	770	I3	110	I2	870	270

I - Total number of isomers < - Below detection limit

* - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel; SF - Shirt Factory Creek

Table 5: cont'd.

Station	Depth (cm)	*	Date	T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
0+732		W	1995/06	160	I7	38	I4	57	I4	5.9	I3	64	I6	24	I5	220	I2	79	I2	270	290
0+732	0 -12		1995/10	220	I10	54	I5	71	I7	8.5	I4	55	I6	16	I5	180	I4	49	I2	290	180
0+732	12-25		1995/10	620	I12	180	I6	380	I9	56	I8	260	I9	140	I6	780	I4	310	I2	1100	1100
0+732	0 -10		1996/05	510	I13	120	I6	180	I7	17	I4	130	I8	54	I6	460	I3	170	I2	620	630
0+732	20-30		1996/05	1700	I13	270	I6	680	I10	71	I7	430	I9	98	I6	1300	I3	220	I2	1600	750
0+720E	Surface	E	1996/05	31	I8	9.9	I4	17	I3	1.2	I1	14	I3	9	I5	43	I2	35	I2	49	140
0+738		E	1995/06	93	I6	26	I4	30	I3	2.3	I1	22	I3	14	I4	65	I2	66	I2	84	230
0+750		W	1995/06	240	I8	85	I4	89	I5	11	I3	220	I6	42	I5	1000	I3	180	I2	1300	620
0+750			1995/10	380	I11	96	I6	120	I7	27	I5	150	I9	51	I6	830	I4	150	I2	1300	560
0+750	0 -7		1996/05	470	I11	140	I4	170	I8	46	I5	160	I6	70	I7	740	I3	370	I2	900	1500
0+750	7 -14		1996/05	740	I10	230	I5	270	I7	49	I6	290	I6	89	I6	1100	I3	260	I2	1200	910
0+785		C	1995/06	150	I8	41	I4	62	I4	12	I6	60	I6	24	I6	180	I2	90	I2	200	340
0+785			1995/10	96	I7	36	I4	39	I4	9.3	I5	34	I5	19	I5	90	I3	69	I2	110	440
0+800	Surface	E	1996/05	39	I7	5.9	I2	20	I4	1	<	48	I3	3.4	I2	68	I2	20	I2	53	48
Stn 20	0 -15		1995/06	66	I6	16	I4	34	I4	2	<	24	I5	8.7	I3	53	I2	36	I2	54	130
Stn 20	15-30		1995/06	300	I10	69	I5	130	I6	51	I5	310	I6	56	I5	370	I3	140	I2	240	560
Stn 21			1995/06	77	I6	18	I4	25	I4	3	I2	27	I5	11	I3	76	I2	62	I2	93	280
21 Pond			1995/11	790	I11	180	I5	340	I9	50	I7	330	I7	95	I5	870	I3	230	I2	990	810
21 Strm			1995/11	77	I8	24	I4	28	I3	7.2	I5	17	I3	7.8	I3	66	I2	28	I2	82	150
21-S	0 -10		1996/05	95	I7	20	I4	26	I3	2	<	20	I3	5.6	I2	68	I2	26	I2	64	110
21-S	10-20		1996/05	100	I7	23	I4	35	I3	2	<	26	I3	13	I4	90	I2	41	I2	90	160
Stn 22			1995/06	97	I7	26	I4	34	I3	4.4	I2	33	I4	19	I4	110	I2	73	I2	130	320
Stn 23			1995/06	76	I7	27	I5	31	I3	6.8	I3	30	I5	19	I5	80	I2	62	I2	84	280

I - Total number of isomers < - Below detection limit

* - Location in stream; C - Centre of channel; W - West side of channel; E - East side of channel

Table 6: Sediment Concentrations of 2,3,7,8-Substituted Isomers. Canagagigue Creek 1995-96. (All values in pg/g (ppt)).

Station	Depth (cm)	*	Date	2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	1,2,3,4,7,8-H_6CDF	1,2,3,6,7,8-H_6CDF	2,3,4,6,7,8-H_6CDF	1,2,3,7,8,9-H_6CDF	1,2,3,4,7,8-H_6CDF
I-TEF				*0.1*	*1*	*0.05*	*0.5*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Stn 1			1995/06	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+30		W	1995/06	2 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+30			1995/10	1.8	1 <	1 <	1 <	1 <	1.1	1 <	1 <	1 <	1 <
0+30	0 -10		1996/05	1.3	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+30	10-20		1996/05	3.9	1 <	2	1.8	1 <	5.3	2.3	1.9	1 <	1 <
0+120	0 -8	E	1995/11	2.1	1 <	1 <	1 <	1 <	1 <	2	1.9	1 <	1 <
0+120	8 -20		1995/11	1.7	1 <	1 <	1 <	1 <	1 <	2	2.5	1 <	1 <
0+240E	0 -10	E	1996/05	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+240E	10-20	E	1996/05	2 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+244		W	1995/06	1.7	2.2	1 <	1 <	1 <	1 <	1 <	1.3	1 <	1 <
0+270		W	1995/06	4.5	3.4	1 <	1 <	1.5	2.1	1.6	3	1 <	1 <
0+285		W	1995/10	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+330C		C	1995/06	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+320		E	1995/06	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+330W		W	1995/06	2	1	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+345	Surface	W	1996/05	2.4	2 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+360	0 -10	E	1996/05	23	21	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+360	10-20		1996/05	23	23	1 <	1 <	1 <	1 <	1 <	1 <	1 <	1 <
0+397		E	1995/06	47	55	1 <	1 <	1.9	1.8	1 <	2.7	1 <	1 <
0+397	Surface		1996/05	19	22	1.4	1.3	1.9	1.2	1.2	1.2	1 <	1 <

< - Below detection limit

* - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel

Table 6: cont'd.

Station	Depth (cm)	*	Date	2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	1,2,3,4,7,8-H_6CDF	1,2,3,6,7,8-H_6CDF	2,3,4,6,7,8-H_6CDF	1,2,3,7,8,9-H_6CDF	1,2,3,4,7,8-H_6CDF
I-TEF				*0.1*	*1*	*0.05*	*0.5*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
0+406		W	1995/06	18	21	1<	1<	1<	1.5	1<	1.8	1<	1<
0+432		SF	1995/06	4.6	3	1<	1<	1<	2.3	2	3.6	1<	1<
0+438		SF	1995/11	3.9	2.6	1<	1<	1<	1<	1<	2<	1<	1<
0+468		SF	1995/11	2	1<	1<	2	1<	4.1	3.3	6.4	1<	2<
0+456		SF	1995/10	1<	4.9	1<	1	1<	1.8	1.2	2<	1<	1<
0+450	Surface	E	1996/05	18	15	1<	1<	1<	1<	1<	1<	1<	1<
0+494		W	1995/06	15	17	1<	2.6	2	4.4	3.6	7.7	1<	1.9
0+565		W	1995/06	15	14	1<	1.5	1<	2.3	1.4	2.9	1<	1<
0+600		E	1995/06	11	11	1<	1<	1<	1<	1<	1<	1<	1<
0+590		E	1995/10	3<	23	1<	1<	1<	1<	1<	1<	1<	1<
0+630W		W	1995/06	17	13	1<	1<	1<	1.2	1<	2.1	1<	1<
0+630W		W	1995/10	10<	26	1<	1.1	1.3	2.6	1.7	2.8	1<	1<
0+630W	Surface	W	1996/05	130	27	1<	3.2	4.5	9.5	5.4	7.3	1<	1<
0+630E	Surface	E	1996/05	8.4	7.8	1<	1<	1<	1<	1<	1<	1<	1<
0+668		W	1995/10	4<	16	1<	1<	1	1.5	1.1	2<	1<	1<
0+710	0 -10	W	1996/05	96	71	2.4	3.8	6.3	8.4	5.2	6.5	1<	1.7
0+710	10-20		1996/05	190	160	2.4	6.4	9.6	20	8.8	12	1<	2
0+710	20-30		1996/05	310	290	17	8.6	16	23	11	21	1<	2.1
0+710	30-37		1996/05	39	24	1<	2.8	8.6	8.1	4	5.6	1<	2

< - Below detection limit

* - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel; SF - Shirt Factory Creek

Table 6: cont'd.

Station	Depth (cm)	*	Date	2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	[illegible]-H_6CDF	1,2,3,6,7,8-H_6CDF	2,3,4,6,7,8-H_6CDF	1,2,3,7,8,9-H_6CDF	1,2,3,4,7,8-H_6CDF
I-TEF				*0.1*	*1*	*0.05*	*0.5*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
0+732		W	1995/06	23	20	1<	1<	1.5	2.6	1.8	3.7	1<	1<
0+732	0 -12		1995/10	8<	24	1.1	1.1	1.1	4.2	2.2	2<	1.6	1<
0+732	12-25		1995/10	20<	100	1	3.9	6.8	9.2	6.5	9.2	1<	2.6
0+732	0 -10		1996/05	61	54	1<	1.9	3.2	4.6	3.3	4.1	1<	1.3
0+732	20-30		1996/05	220	170	2.4	6.8	11	20	9.4	14	1<	2.3
0+720E	Surface	E	1996/05	5.3	5.1	1<	1<	1<	1<	1<	1<	1<	1<
0+738		E	1995/06	12	12	1<	1<	1<	1<	1<	2	1<	1<
0+750		W	1995/06	34	59	1<	1.7	3.1	3.8	2.9	6.5	1<	1<
0+750			1995/10	10<	40	1<	1.6	2.1	4	2.8	4.9	1<	1.3
0+750	0 -7		1996/05	60	81	8.9	7.4	9.1	7.1	6.2	6.4	1<	4.1
0+750	7 -14		1996/05	120	140	1.8	2.8	6.4	10	5.5	7.4	1<	2.8
0+785		C	1995/06	23	23	1<	1<	1.7	2.4	1.7	3.3	1<	1<
0+785			1995/10	4<	13	1<	1<	1	1.7	1.3	2<	1<	1<
0+800	Surface	E	1996/05	5.3	3.8	1<	1<	1<	1<	1<	1<	1<	1<
Stn 20	0 -15		1995/06	8.8	8	1<	1<	1	1.1	1<	2	1<	1<
Stn 20	15-30		1995/06	36	25	1<	1.8	3.3	3.8	1.8	4.1	1<	1<
Stn 21			1995/06	7.8	5.9	1<	1	1	2.4	1<	2.8	1<	1<
21 Pond			1995/11	94	110	2.5	4<	5.4	10	16	14	1<	1<
21 Strm			1995/11	9.2	7	1<	1<	1<	1<	1<	1<	1<	1<
21-S	0 -10		1996/05	8.3	6.4	1<	1<	1<	1<	1<	1<	1<	1<
21-S	10-20		1996/05	12	8.3	1<	1<	1<	1<	1<	2<	1<	1<
Stn 22			1995/06	11	8.3	1<	1	1	2	1<	2.4	1<	1<
Stn 23			1995/06	9	6.9	1<	1	1	1.6	1.1	2	1<	1<

< - Below detection limit

* - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel

Table 6: cont'd.

Station	Depth (cm)	*	Date	1,2,3,6,7,8-H_6CDD	1,2,3,7,8,9-H_6CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF				*0.1*	*0.1*	*0.01*	*0.01*	*0.01*	*0.001*	*0.001*	
Stn 1			1995/06	1 <	1 <	2 <	1 <	4.1	2.4	20	0.1
0+30		W	1995/06	1 <	1 <	5.2	1 <	16	11	110	0.3
0+30			1995/10	1 <	1 <	5.1	1 <	12	13	79	0.4
0+30	0 -10		1996/05	1.3	1.3	9.8	1 <	25	26	150	0.9
0+30	10-20		1996/05	1.6	1.5	15	2.7	29	45	190	
0+120	0 -8	E	1995/11	1.9	2 <	11	1 <	27	27	170	1.4
0+120	8 -20		1995/11	2.3	1.7	7.5	1 <	20	17	110	1.4
0+240E	0 -10	E	1996/05	1 <	1 <	5.2	1 <	17	10	130	0.4
0+240E	10-20	E	1996/05	1 <	1 <	6.6	1 <	13	14	83	0.3
0+244		W	1995/06	1 <	1 <	22	1 <	17	48	110	3.1
0+270		W	1995/06	7.2	3.9	53	1.7	69	130	2200	9.8
0+285		W	1995/10	1 <	1 <	10	1 <	11	25	67	0.2
0+330C		C	1995/06	1 <	1 <	5.8	1 <	15	13	88	0.8
0+320		E	1995/06	1 <	1 <	7.3	1 <	16	18	110	1.0
0+330W		W	1995/06	1 <	1 <	7.4	1 <	11	20	87	2.2
0+345	Surface	W	1996/05	2	1.9	61	1 <	45	270	480	2.4
0+360	0 -10	E	1996/05	1.6	1 <	33	1 <	73	79	1600	26.2
0+360	10-20		1996/05	1 <	1 <	31	1 <	21	73	150	26.0
0+397		E	1995/06	3	1.6	70	1 <	35	230	220	63.1
0+397	Surface		1996/05	1.2	1 <	32	1 <	13	88	89	26.7

< - Below detection limit

* - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel

Table 6: cont'd.

Station	Depth (cm)	*	Date	1,2,3,6,7,8-H_6CDD	1,2,3,7,8,9-H_6CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF				*0.1*	*0.1*	*0.01*	*0.01*	*0.01*	*0.001*	*0.001*	
0+406		W	1995/06	2.1	1.4	34	1 <	43	100	520	24.7
0+432		SF	1995/06	3.7	3	30	1 <	58	87	430	6.3
0+438		SF	1995/11	3.1	2	23	1 <	53	64	710	5.0
0+468		SF	1995/11	5.8	5.5	38	2	110	120	1200	6.5
0+456		SF	1995/10	2.9	1.9	31	1 <	41	88	270	7.3
0+450	Surface	E	1996/05	1.6	1.2	33	1 <	22	90	150	17.9
0+494		W	1995/06	7.6	6	150	3	130	470	950	28.1
0+565		W	1995/06	2.8	1.8	42	1 <	36	120	250	18.5
0+600		E	1995/06	1 <	1 <	17	1 <	15	50	110	12.6
0+590		E	1995/10	1.3	1 <	29	1 <	12	84	77	23.7
0+630W		W	1995/06	2.3	1 <	29	1 <	27	76	170	16.1
0+630W		W	1995/10	3.4	1.8	170	2.7	38	600	220	31.4
0+630W	Surface	W	1996/05	3.5	2.2	160	4.2	46	100	280	49.1
0+630E	Surface	E	1996/05	1 <	1 <	16	1 <	13	41	85	9.1
0+668		W	1995/10	3.8	1.5	52	1.6	35	150	180	18.5
0+710	0 -10	W	1996/05	10	4.8	240	4.2	75	640	430	93.7
0+710	10-20		1996/05	13	5.5	580	9.7	100	1400	550	202.1
0+710	20-30		1996/05	14	5.8	610	11	88	1300	430	350.7
0+710	30-37		1996/05	7.2	3.9	350	4.1	62	870	270	42.0

< - Below detection limit

* - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel; SF - Shirt Factory Creek

Table 6: cont'd.

Station	Depth (cm)	*	Date	1,2,3,6,7,8-H_6CDD	1,2,3,7,8,9-H_6CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF				*0.1*	*0.1*	*0.01*	*0.01*	*0.01*	*0.001*	*0.001*	
0+732		W	1995/06	3.7	2	92	1<	45	270	290	26.4
0+732	0 -12		1995/10	2.6	1.4	75	6.6	27	290	180	27.9
0+732	12-25		1995/10	20	9	330	6.9	180	1100	1100	118.4
0+732	0-10		1996/05	8.3	3.4	200	2.9	110	620	630	69.5
0+732	20-30		1996/05	15	6	570	9.7	130	1600	750	217.4
0+720E	Surface	E	1996/05	1.1	1	20	1<	18	49	140	6.4
0+738		E	1995/06	2.1	1.7	27	1<	33	84	230	15.1
0+750		W	1995/06	7.4	3.9	400	4.4	110	1300	620	74.3
0+750			1995/10	11	3	320	5	87	1300	560	50.5
0+750	0 -7		1996/05	14	6.1	290	4.5	220	900	1500	108.0
0+750	7 -14		1996/05	13	5.8	470	6.2	150	1200	910	170.1
0+785		C	1995/06	3.4	2.1	72	1<	46	200	340	27.2
0+785			1995/10	2.5	2	41	1<	36	110	440	15.6
0+800	Surface	E	1996/05	1<	1<	29	1<	7.3	53	48	4.3
Stn 20	0 -15		1995/06	1.6	1<	21	1<	18	54	130	10.4
Stn 20	15-30		1995/06	6.6	3.4	150	1.9	75	240	560	36.2
Stn 21			1995/06	1.9	1<	31	1<	34	93	280	8.9
21 Pond			1995/11	11	5.7	390	8.3	120	990	810	134.9
21 Strm			1995/11	1<	1<	28	1<	16	82	150	8.6
21-S	0 -10		1996/05	1<	1<	30	1<	15	64	110	7.8
21-S	10-20		1996/05	1.6	1<	39	1<	22	90	160	10.5
Stn 22			1995/06	2.9	2.1	42	1<	40	130	320	12.1
Stn 23			1995/06	2.3	1.8	33	1<	35	84	280	10.2

< - Below detection limit * - Location in stream: C - Centre of channel; W - West side of channel; E - East side of channel

Table 8: Dioxin and Furan Concentrations in Exposed Stream Banks. Canagagigue Creek 1995-96. (All values in pg/g (ppt)). Concentrations listed are totals for each congener group.

Station	Depth (cm)	*	Date	T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
0+310	0 -10	W	1996/05	22	I8	13	I4	24	I5	4.7	I2	71	I6	40	I6	210	I3	170	I2	190	4100
127-S	0 -10	W	1996/10	9	I4	11	I4	14	I4	8.6	I5	53	I6	46	I6	150	I2	340	I2	150	2300
127-S	10-20		1996/10	31	I8	36	I5	25	I3	22	I7	99	I6	94	I6	340	I3	860	I2	320	6300
0+397	0 -10	E	1996/05	140	I8	40	I4	37	I3	5	I3	21	I4	8.3	I4	77	I2	33	I2	94	150
0+397	10-20		1996/05	76	I6	15	I4	11	I2	4.2	I3	13	I4	9.2	I4	48	I2	33	I2	54	110
0+397	20-30		1996/05	190	I11	96	I4	60	I4	20	I6	40	I7	25	I5	110	I3	79	I2	120	280
0+450	0 -10	E	1996/05	220	I8	58	I4	54	I3	11	I4	32	I4	18	I5	120	I2	59	I2	130	220
0+450	10-20		1996/05	470	I8	77	I4	76	I6	18	I6	24	I5	15	I5	71	I2	32	I2	79	100
0+590	0 -10	E	1996/05	35	I6	11	I3	20	I4	4.5	I3	21	I6	20	I5	52	I2	74	I2	41	230
0+590	10-20		1996/05	32	I8	16	I4	25	I4	4.6	I3	27	I6	15	I5	120	I2	59	I2	94	180
0+565		W	1995/10	300	I12	120	I6	78	I5	100	I5	47	I5	40	I5	150	I3	90	I2	190	240
0+565	0 -12		1996/05	230	I9	34	I4	76	I7	8.7	I4	100	I7	31	I6	370	I3	190	I2	340	520
0+565	12-24		1996/05	58	I9	38	I5	99	I8	15	I4	130	I7	39	I6	260	I3	130	I2	220	360
0+630W		W	1995/06	120	I8	27	I4	38	I4	3.2	I2	31	I5	14	I4	74	I2	54	I2	76	170
0+630W	Surface		1996/05	1400	I11	44	I6	260	I7	16	I3	140	I8	23	I5	300	I3	100	I2	100	280
0+800	0 -12	E	1996/05	85	I6	17	I4	24	I4	2.8	I2	21	I6	12	I5	70	I2	54	I2	75	190
0+800	12-24		1996/05	64	I7	14	I4	20	I4	2	<	17	I4	12	I5	65	I2	50	I2	80	160

I - Total number of isomers

* - Location in stream: W - West side of channel; E - East side of channel

Table 7: DDT and Metabolites in Exposed Bank Sediments/Soils. 1996.

Station	Depth		Date	pp-DDE	pp-DDD	op-DDT	pp-DDT	Total DDT	TOC mg/g
Bank cores									
0+310	0-10cm	West	1996/05	110	150	70	990	1060	
0+310	10-24cm		1996/05	590	5<W	10<T	5<W	10<T	
127-S	0 -10	West	1996/10						
127-S	10-20		1996/10						
0+397	0-10cm	East	1996/05	10	10<T	5<W	5<W	5<W	
0+397	10-20cm		1996/05	14	5<W	5<W	5<W	5<W	
0+397	20-30cm		1996/05	13	35<T	5<W	5<W	5<W	
0+450	0-10cm	East	1996/05	12	10<T	5<W	35<T	35<T	
0+450	10-20cm		1996/05	22	5<W	5<W	5<W	5<W	
0+565	0-12cm	West	1996/05	63	40<T	10<T	70	80	
0+565	12-24cm		1996/05	1<W	20<T	10<T	10<T	20	
0+590	0-10 cm	East	1996/05	6<T	35<T	20<T	25<T	45	
0+590	10-20 cm		1996/05	7<T	10<T	5<W	5<W	5<W	
0+800	0-12cm	East	1996/05	16	780	10<T	120	130	
0+800	12-24cm		1996/05	19	65	20<T	160	180	

Table 8: Dioxin and Furan Concentrations in Exposed Stream Banks. Canagagigue Creek 1995-96. (All values in pg/g (ppt)). Concentrations listed are totals for each congener group.

Station	Depth (cm)	*	Date	T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
0+310	0 -10	W	1996/05	22	I8	13	I4	24	I5	4.7	I2	71	I6	40	I6	210	I3	170	I2	190	4100
127-S	0 -10	W	1996/10	9	I4	11	I4	14	I4	8.6	I5	53	I6	46	I6	150	I2	340	I2	150	2300
127-S	10-20		1996/10	31	I8	36	I5	25	I3	22	I7	99	I6	94	I6	340	I3	860	I2	320	6300
0+397	0 -10	E	1996/05	140	I8	40	I4	37	I3	5	I3	21	I4	8.3	I4	77	I2	33	I2	94	150
0+397	10-20		1996/05	76	I6	15	I4	11	I2	4.2	I3	13	I4	9.2	I4	48	I2	33	I2	54	110
0+397	20-30		1996/05	190	I11	96	I4	60	I4	20	I6	40	I7	25	I5	110	I3	79	I2	120	280
0+450	0 -10	E	1996/05	220	I8	58	I4	54	I3	11	I4	32	I4	18	I5	120	I2	59	I2	130	220
0+450	10-20		1996/05	470	I8	77	I4	76	I6	18	I6	24	I5	15	I5	71	I2	32	I2	79	100
0+590	0 -10	E	1996/05	35	I6	11	I3	20	I4	4.5	I3	21	I6	20	I5	52	I2	74	I2	41	230
0+590	10-20		1996/05	32	I8	16	I4	25	I4	4.6	I3	27	I6	15	I5	120	I2	59	I2	94	180
0+565		W	1995/10	300	I12	120	I6	78	I5	100	I5	47	I5	40	I5	150	I3	90	I2	190	240
0+565	0 -12		1996/05	230	I9	34	I4	76	I7	8.7	I4	100	I7	31	I6	370	I3	190	I2	340	520
0+565	12-24		1996/05	58	I9	38	I5	99	I8	15	I4	130	I7	39	I6	260	I3	130	I2	220	360
0+630W		W	1995/06	120	I8	27	I4	38	I4	3.2	I2	31	I5	14	I4	74	I2	54	I2	76	170
0+630W	Surface		1996/05	1400	I11	44	I6	260	I7	16	I3	140	I8	23	I5	300	I3	100	I2	100	280
0+800	0 -12	E	1996/05	85	I6	17	I4	24	I4	2.8	I2	21	I6	12	I5	70	I2	54	I2	75	190
0+800	12-24		1996/05	64	I7	14	I4	20	I4	2	<	17	I4	12	I5	65	I2	50	I2	80	160

I - Total number of isomers

* - Location in stream: W - West side of channel; E - East side of channel

Table 9: Concentrations of 2,3,7,8-Substituted Isomers in Exposed Stream Banks. Canagagigue Creek 1995-96. (All values in pg/g (ppt)).

Station	Depth (cm)	*	Date	2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	1,2,3,4,7,8-H_6CDF	1,2,3,6,7,8-H_6CDF	2,3,4,6,7,8-H_6CDF	1,2,3,7,8,9-H_6CDF	1,2,3,4,7,8-H_6CDF
I-TEF				*0.1*	*1*	*0.05*	*0.5*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
0+310	0 -10	W	1996/05	4.1	4.1	1.3	1.5	2.4	3.1	2.6	3.9	2<	2.6
127-S	0 -10	W	1996/10	2<	1.8	1<	1<	1<	1.8	1.2	2	1<	2.1
127-S	10-20		1996/10	5	4.7	1<	1<	2.5	2.9	1.8	3.6	1<	4.3
0+397	0 -10	E	1996/05	19	19	1<	1<	1<	1<	1<	1<	1<	1<
0+397	10-20		1996/05	8.5	7.3	1<	1<	1<	1<	1<	1<	1<	1<
0+397	20-30		1996/05	19	21	1<	1<	2.7	1.8	1.9	1.8	1<	1<
0+450	0 -10	E	1996/05	26	24	1<	1<	1.5	1.8	1<	1<	1<	1<
0+450	10-20		1996/05	37	16	1<	1<	1.6	1<	1<	1.8	1<	1<
0+590	0 -10	E	1996/05	5.6	8.7	1<	1<	1<	1.5	1.1	1.1	1<	1<
0+590	10-20		1996/05	7.9	11	1<	1<	1<	1.4	1.1	1.1	1<	1<
0+565		W	1995/10	10<	37	1<	1<	2.5	1.7	1.3	2<	1<	1<
0+565	0 -12		1996/05	26	31	1<	1.5	2.1	3.5	2.7	3.1	1<	1.6
0+565	12-24		1996/05	16	28	1<	1.9	2.4	5.4	3.3	3.8	1<	1.5
0+630W		W	1995/06	17	13	1<	1<	1<	1.2	1<	2.1	1<	1<
0+630W	Surface		1996/05	130	27	1<	3.2	4.5	9.5	5.4	7.3	1<	1<
0+800	0 -12	E	1996/05	9.7	7.7	1<	1<	1<	1.2	1<	1.2	1<	1<
0+800	12-24		1996/05	5.9	4.8	1<	1<	1<	1.1	1<	1<	1<	1<

< - Below detection limit.

* - Location in stream: W - West side of channel; E - East side of channel

Table 9: cont'd.

Station	Depth (cm)	*	Date	1,2,3,6,7,8-H_6CDD	1,2,3,7,8,9-H_6CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF				*0.1*	*0.1*	*0.01*	*0.01*	*0.01*	*0.001*	*0.001*	
0+310	0 -10	W	1996/05	7.6	5.1	92	2.4	100	190	4100	15.3
127-S	0 -10	W	1996/10	6.8	4.9	54	2<	200	150	2300	8.7
127-S	10-20		1996/10	15	10	120	4.1	510	320	6300	23.5
0+397	0 -10	E	1996/05	1.3	1<	33	1<	20	94	150	21.8
0+397	10-20		1996/05	1.2	1<	22	1<	17	54	110	8.8
0+397	20-30		1996/05	2.9	2.2	47	1.1	42	120	280	26.6
0+450	0 -10	E	1996/05	2.3	1.7	54	1<	32	130	220	29.1
0+450	10-20		1996/05	1.6	1	32	1<	17	79	100	21.6
0+590	0 -10	E	1996/05	2.1	1.9	23	1<	34	41	230	10.9
0+590	10-20		1996/05	1.8	1.3	47	1<	28	94	180	13.5
0+565		W	1995/10	5.7	2.6	62	1.3	55	190	240	41.0
0+565	0 -12		1996/05	4.5	2.7	150	2.2	67	340	520	40.3
0+565	12-24		1996/05	5.3	3.2	120	2.1	63	220	360	36.4
0+630W		W	1995/06	2.3	1<	29	1<	27	76	170	16.1
0+630W	Surface		1996/05	3.5	2.2	160	4.2	46	100	280	49.1
0+800	0 -12	E	1996/05	1.7	1.3	31	1<	26	75	190	10.0
0+800	12-24		1996/05	1.4	1.1	28	1<	23	80	160	6.5

< - Below detection limit.

* - Location in stream: W - West side of channel; E - East side of channel

Table 10: PCB and Organochlorine Pesticides in Floodplain Sediments/Soils. Canagagigue Creek. 1996.
All values in ng/g dry weight unless indicated otherwise.

Station	Depth	PCB, total	Heptachlor	Aldrin	pp-DDE	Mirex	α-BHC	β-BHC	γ-BHC	α-Chlordane	γ-Chlordane	Oxychlordane
FP-C1	0 -10 cm	20<W	1<W	1<W	1<W	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-C2	0 -10 cm	20<W	1<W	1<W	1<W	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-1	0 -12 cm	20<W	1<W	1<W	30	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-1	12-24 cm	40P40	1<W	1<W	25	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-2	0 -12 cm	140P40	1<W	1<W	39	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-2	12-24 cm	20<W	1<W	1<W	25	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Sediment												
FP-3	0 -12 cm	20<W	1<W	1<W	36	5<W	1<W	4<T	2<T	2<W	2<W	2<W
FP-3	12-24 cm	20<W	1<W	1<W	53	5<W	1<W	1<W	1<W	2<W	2<W	2<W
Soil												
FP-3	0 -10 cm	20<W	1<W	1<W	41	5<W	1<W	1<W	2<T	2<W	2<W	2<W
FP-3	10-20 cm	40P40	1<W	1<W	66	5<W	1<W	1<W	2<T	2<W	2<W	2<W
FP-4	0 -10 cm	20<W	1<W	1<W	72	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-5	0 -10 cm	20<W	1<W	1<W	150	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-6	0 -10 cm	20<W	1<W	1<W	76	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-7	0 -10 cm	20<W	1<W	1<W	30	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-8	0 -10 cm	20<W	1<W	1<W	170	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-8	10-30 cm	20<W	1<W	1<W	200	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-9	0 -10 cm	20<W	1<W	1<W	110	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-9	10-20 cm	20<W	1<W	1<W	140	5<W	1<W	1<W	1<W	2<W	2<W	2<W
FP-10	0 -10 cm	20<W	1<W	1<W	49	5<W	1<W	1<W	1<W	2<W	2<W	2<W

<W = below detection limit <T = trace amount

Table 10: cont'd.

Station	Depth	op-DDT	pp-DDD	pp-DDT	op-DDT + pp-DDT	Mathoxy-chlor	Hepta-chlor epoxide	Endosul-phan-I	Dieldrin	Endrin	Endosul-phan-II	Endosul-phan sulphate	TOC mg/g
FP-C1	0 -10 cm	5<W	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	14
FP-C2	0 -10 cm	5<W	5<W	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	24
FP-1	0 -12 cm	35	10	160	195	5<W	1<W	2<W	2<W	20<T	4<W	20<T	
FP-1	12-24 cm	10	55	20	30	5<W	1<W	2<W	2<W	16<T	4<W	4<W	
FP-2	0 -12 cm	5<W	60	190	190	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
FP-2	12-24 cm	5<W	55	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
Sedimant													
FP-3	0 -12 cm	10<T	75	35	45	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
FP-3	12-24 cm	5<W	140	5<W	5<W	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
Soil													
FP-3	0 -10 cm	15<T	15<T	200	215	5<W	1<W	2<W	2<W	4<W	4<W	4<W	58
FP-3	10-20 cm	30<T	65	890	920	5<W	1<W	2<W	2<W	4<W	4<W	4<W	39
FP-4	0 -10 cm	10<T	25<T	100	110	5<W	1<W	2<W	2<W	4<W	4<W	4<W	66
FP-5	0 -10 cm	10<T	400	500	510	5<W	1<W	2<W	2<W	4<W	4<W	4<W	46
FP-6	0 -10 cm	40<T	50	200	240	5<W	1<W	2<W	2<W	4<W	4<W	4<W	43
FP-7	0 -10 cm	5<W	70	40<T	40<T	5<W	1<W	2<W	2<W	4<W	4<W	4<W	52
FP-8	0 -10 cm	15<T	50	100	115	5<W	1<W	2<W	2<W	4<W	4<W	4<W	37
FP-8	10-30 cm	20<T	200	200	220	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
FP-9	0 -10 cm	20<T	20<T	85	105	5<W	1<W	2<W	2<W	4<W	4<W	4<W	54
FP-9	10-20 cm	15<T	55	120	135	5<W	1<W	2<W	2<W	4<W	4<W	4<W	
FP-10	0 -10 cm	20<T	35<T	420	440	5<W	1<W	2<W	2<W	4<W	4<W	4<W	26

<W = below detection limit <T = trace amount

Table 11: Dioxins and Furans in Floodplain Sediments/Soils. Canagagigue Creek. 1996 (All values in pg/g (ppt)). Concentrations listed are totals for each congener group.

Station	Depth	T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
FP-C1	0 -10 cm	1 <		1 <		1 <		1 <		1.1	I1	2.3	I2	1.7	I1	7.4	I2	2.9	26
FP-C2	0 -10 cm	1 <		1 <		1 <		1 <		1.2	I1	2.9	I2	1.1	I1	8.8	I2	2.3	24
FP-1	0 -12 cm	150	I7	29	I4	28	I5	2.7	I2	35	I6	16	I5	170	I2	76	I2	240	370
FP-1	12-24 cm	41	I6	18	I4	31	I5	3.9	I3	52	I7	24	I6	230	I3	120	I2	230	550
FP-2	0 -12 cm	95	I9	23	I4	33	I5	4.4	I3	40	I6	26	I6	110	I2	88	I2	93	460
FP-2	12-24 cm	27	I7	12	I2	27	I6	6.2	I4	50	I6	26	I6	160	I3	94	I2	160	420
Sediment																			
FP-3	0 -12 cm	210	I13	61	I5	80	I7	7.7	I3	63	I7	24	I5	180	I3	60	I2	240	280
FP-3	12-24 cm	280	I13	100	I6	200	I8	27	I5	130	I8	42	I5	340	I3	78	I2	430	420
Soil																			
FP-3	0 -10 cm	240	I10	63	I4	78	I6	13	I5	65	I6	31	I5	190	I2	83	I2	220	350
FP-3	10-20 cm	410	I12	93	I4	130	I7	21	I6	86	I6	43	I5	180	I3	110	I2	200	420
FP-4	0 -10 cm	190	I10	66	I4	63	I5	18	I6	68	I6	52	I5	180	I3	75	I2	200	180
FP-5	0 -10 cm	320	I14	150	I6	200	I8	37	I6	340	I7	57	I5	2200	I3	150	I2	3000	410
FP-6	0 -10 cm	250	I13	71	I5	75	I6	17	I7	57	I6	24	I5	180	I3	70	I2	170	270
FP-7	0 -10 cm	170	I12	49	I5	46	I3	13	I7	34	I6	20	I5	84	I2	44	I2	78	140
FP-8	0 -10 cm	440	I14	110	I5	170	I7	33	I6	140	I7	50	I6	380	I3	95	I2	270	330
FP-8	10-30 cm	970	I14	210	I5	130	I8	41	I6	200	I9	58	I6	510	I3	110	I2	400	350
FP-9	0 -10 cm	320	I14	89	I5	110	I7	24	I6	100	I7	46	I6	300	I3	89	I2	260	270
FP-9	10-20 cm	390	I14	110	I5	120	I7	23	I6	110	I7	53	I6	270	I3	110	I2	260	350
FP-10	0 -10 cm	140	I10	41	I5	38	I3	7.1	I3	32	I6	13	I5	110	I2	38	I2	95	150

I = Total number of isomers detected

Table 12: Concentrations of 2,3,7,8-Substituted Isomers in Floodplain Sediments/Soils. Canagagigue Creek. 1996. (All values in pg/g (ppt) dry weight).

Station	Depth	2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	1,2,3,4,7,8-H_6CDF	1,2,3,6,7,8-H_6CDF	2,3,4,6,7,8-H_6CDF	1,2,3,7,8,9-H_6CDF	1,2,3,4,7,8-H_6CDF
I-TEF		*0.1*	*1*	*0.05*	*0.5*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
FP-C1	0 -10 cm	1<	1<	1<	1<	1<	1<	1<	1<	1<	1<
FP-C2	0 -10 cm	1<	1<	1<	1<	1<	1<	1<	1<	1<	1<
FP-1	0 -12 cm	17	13	1<	1<	1.1	1.4	1.1	1.2	1<	1<
FP-1	12-24 cm	8.3	13	1<	1<	1.3	1.9	1.6	1.8	1<	1.2
FP-2	0 -12 cm	10	8.6	1<	1<	1.2	1.8	1.4	1.6	1<	1.2
FP-2	12-24 cm	7.2	10	1<	1.1	1.4	2.5	2.3	2.9	1<	1.2
Sediment											
FP-3	0 -12 cm	27	23	1<	1.1	1.6	2.5	3.3	2.5	1<	1<
FP-3	12-24 cm	56	65	1<	1.9	3.1	5.2	6.2	5.3	1<	1<
Soil											
FP-3	0 -10cm	24	16	1<	1.1	2<	2.9	1.8	2.9	1<	1<
FP-3	10-20 cm	43	26	1<	1.6	2.4	4	2.4	3.9	1<	1<
FP-4	0 -10 cm	17	13	1<	1	2.1	2.8	1.9	2.4	1<	1<
FP-5	0 -10 cm	67	63	1.4	2.7	3.2	6.5	6.4	9.8	1<	1<
FP-6	0 -10 cm	27	25	1<	1.1	1.8	2.5	1.7	2.4	1<	1<
FP-7	0 -10 cm	17	12	1<	1<	1.4	1.9	1.7	1.8	1<	1<
FP-8	0 -10 cm	72	39	1<	2.4	3.4	5.2	3.2	5.5	1<	1.2
FP-8	10-30 cm	91	44	1<	2.6	3.9	5.7	3.7	7.4	1<	1.3
FP-9	0 -10 cm	39	33	1<	1.6	2.5	3.9	2.6	4.1	1<	1.2
FP-9	10-20 cm	39	36	1<	1.7	2.7	4.4	2.9	3.5	1<	1.3
FP-10	0 -10 cm	13	9.3	1<	1<	1<	1.5	1.1	1.4	1<	1<

Table 12: cont'd.

2,3,7,8-substituted isomers		1,2,3,6,7,8-H_5CDD	1,2,3,7,8,9-H_6CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF		*0.1*	*0.1*	*0.01*	*0.01*	*0.01*	*0.001*	*0.001*	
FP-C1	0 -10 cm	1<	1<	2<	1<	4.5	2.9	26	0.1
FP-C2	0 -10 cm	1<	1<	2<	1<	4.9	2.3	24	0.1
FP-1	0 -12 cm	2.5	1.7	68	1<	44	240	370	17.8
FP-1	12-24 cm	3.7	2.4	90	1.5	75	230	550	18.1
FP-2	0 -12 cm	3.3	2.6	46	1<	49	93	460	12.9
FP-2	12-24 cm	3.7	2.3	72	1.5	51	160	420	15.3
Sediment									
FP-3	0 -12 cm	2.9	1.8	86	1.7	34	240	280	30.1
FP-3	12-24 cm	4.9	2.4	170	3.2	42	430	420	78.5
Soil									
FP-3	0 -10 cm	3.6	2.4	82	2<	49	220	350	22.2
FP-3	10-20 cm	4.8	3.2	86	1.9	62	200	420	35.2
FP-4	0 -10 cm	5.2	3.3	86	1.4	40	200	180	19.5
FP-5	0 -10 cm	7.6	3.1	920	5.3	84	3000	410	89.6
FP-6	0 -10 cm	3.2	1.9	76	1.4	40	170	270	31.9
FP-7	0 -10 cm	2.1	1.7	36	1<	24	78	140	16.1
FP-8	0 -10 cm	6.5	3.3	170	2.5	56	270	330	54.5
FP-8	10-30 cm	7	3.3	220	3.2	60	400	350	62.8
FP-9	0 -10 cm	5.5	3.2	120	2.1	51	260	270	43.3
FP-9	10-20 cm	5.8	3.5	140	2.5	62	260	350	46.9
FP-10	0 -10 cm	1.9	1.3	41	1<	22	95	150	12.2

Table 13: Dioxin and Furan Concentrations in Water Samples. Floodplain Ponds. (All values in pg/L).

Station		T_4CDF	T_4CDD	P_5CDF	P_5CDD	H_6CDF	H_6CDD	H_7CDF	H_7CDD	O_8CDF	O_8CDD
FP-3		1.8 I1	2<	1<	2<	6<	3<	2<	4<	1<	20<
FP-3	SS	26 I2	8<	19 I3	3<	13 I2	13 I2	69 I2	58 I2	49	250
FP-7		1<	2<	1<	3<	6<	2<	1.7 I1	3<	2.2	10<
FP-7	SS	22 I2	4<	9.4 I3	3<	6 I2	2.4 I1	22 I2	8.2 I1	16	56

Station		2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	1,2,3,4,7,8-H_8CDF	1,2,3,6,7,8-H_8CDF	2,3,4,6,7,8-H_8CDF	1,2,3,7,8,9-H_8CDF	1,2,3,4,7,8-H_8CDF
I-TEF		0.1	1	0.05	0.5	0.5	0.1	0.1	0.1	0.1	0.1
FP-3		1.8	2<	1<	1<	2<	1<	2<	1<	6<	2<
FP-3	SS	5<	6<	1<	1<	3<	3<	3<	3<	6<	3<
FP-7		1<	2<	1<	1<	3<	1<	2<	1<	6<	2<
FP-7	SS	3<	4<	1<	1<	3<	1<	2<	2<	6<	3<

		1,2,3,6,7,8-H_8CDD	1,2,3,7,8,9-H_8CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF		0.1	0.1	0.01	0.01	0.01	0.001	0.001	
FP-3		1<	1<	2<	1<	4<	1<	20<	0.18
FP-3	SS	2<	2<	30	1<	28	49	250	0.88
FP-7		1<	1<	3<	1<	3<	2.2	10<	0.002
FP-7	SS	1<	1<	11	1<	10<	16	56	0.18

I = number of isomers detected

< = below detection limit

Table 14: Major Benthic Macroinvertebrate Taxa. Canagagigue Creek. 1995-96.

All values are in #/m²

Station	Stn 1	Stn 1	Stn 1	Mean	0+30	0+30	0+30	Mean	0+240	0+240	0+240	Mean	0+244	0+244	0+244	Mean
Replicate	Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3	
Year	1995				1995				1996				1995			
PHYLUM NEMATODA																
PHYLUM ANNELIDA																
Class Oligochaeta	8485	30088	27314	21962	1036	911	377	775	581	377	516	491	580	451	793	608
Class Hirudinea																
PHYLUM MOLLUSCA	190	0	0	63												
PHYLUM ARTHROPODA																
Class Malacostraca																
Order Amphipoda																
Order Isopoda	0	0	207	69												
Class Insecta																
Order Coleoptera									22	22	0	14	0	0	50	17
Order Diptera																
Athericidae																
Ceratopogonidae	47	0	0	16												
Chironomidae	427	2192	7863	3494	399	114	538	350	291	161	280	244	322	838	744	635
Dolichopodidae																
Tabanidae																
Psychodidae																
Simuliidae																
Order Ephemeroptera																
Order Hemiptera	47	199	207	151												
Order Lepidoptera																
Order Trichoptera																
Total No Organisms	9385	32479	35591	25818	1435	1082	915	1144	893	560	796	750	902	1289	1587	1259
% Oligochaetes	90	93	77	85	72	84	41	68	65	67	65	66	64	35	50	48
% chironomids	5	7	22	14	28	11	59	31	33	29	35	33	36	65	47	50

Table 14: cont'd.

Station	0+270	0+270	0+270	Mean	0+330C	0+330C	0+330C	Mean	0+320	0+320	0+320	Mean	0+330W	0+330W	0+330W	Mean
Replicate	Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3	
Year	1995				1995				1995				1995			
PHYLUM NEMATODA					75	142	229	149	122	156	102	127	485	149	307	314
PHYLUM ANNELIDA																
Class Oligochaeta	32126	24150	32126	29468	15801	28741	23466	22669	1834	2573	2132	2180	12408	12553	13988	12983
Class Hirudinea	0	598	154	250	150	0	114	88								
PHYLUM MOLLUSCA					0	142	114	85	0	78	0	26	97	0	0	32
PHYLUM ARTHROPODA																
Class Malacostraca																
Order Amphipoda																
Order Isopoda	0	120	461	194	0	0	458	153					194	0	154	116
Class Insecta																
Order Coleoptera	0	478	0	159	0	142	114	85	0	0	102	34	0	0	307	102
Order Diptera																
Athericidae																
Ceratopogonidae																
Chironomidae	6593	0	0	2198	226	425	1259	637	61	78	0	46	1551	747	2921	1740
Dolichopodidae																
Tabanidae																
Psychodidae																
Simuliidae																
Order Ephemeroptera																
Order Hemiptera																
Order Ledidoptera																
Order Trichoptera																
Total No Organisms	32126	25465	32895	30162	16253	29732	25755	23919	2017	2963	2335	2438	14734	13450	17677	15287
% Oligochaetes	100	95	98	98	97	97	91	95	91	87	91	89	84	93	79	85
% chironomids	21	0	0	7	1	1	5	3	3	3	0	2	11	6	17	11

Table 14: cont'd.

Station	0+345	0+345	0+345	Mean	0+360	0+360	0+360	Mean	0+397	0+397	0+397	Mean	0+406	0+406	0+406	Mean
Replicate	Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3	
Year	1996				1996				1996				1995			
PHYLUM NEMATODA									179	576	0	252				
PHYLUM ANNELIDA																
Class Oligochaeta	1506	5208	4304	3637	11908	10658	9146	10570	2331	5764	1357	3151	28790	51203	79547	53180
Class Hirudinea	22	172	646	280	359	0	0	120	36	0	0	12	0	2226	0	742
PHYLUM MOLLUSCA	129	129	43	100					108	0	0	36				
PHYLUM ARTHROPODA																
Class Malacostraca																
Order Amphipoda	0	86	86	57												
Order Isopoda									179	0	0	60				
Class Insecta																
Order Coleoptera	65	172	0	79	215	51	90	119	0	48	0	16				
Order Diptera																
Athericidae																
Ceratopogonidae	86	43	215	115	287	307	45	213	36	384	32	151				
Chironomidae	4369	8479	8737	7195	7102	7327	4663	6364	1219	1057	420	899	872	11873	6533	6426
Dolichopodidae																
Tabanidae													0	371	0	124
Psychodidae																
Simuliidae																
Order Ephemeroptera																
Order Hemiptera																
Order Ledidoptera																
Order Trichoptera																
Total No Organisms	6305	15408	14031	11915	19870	18343	13943	17386	4232	7830	1809	4624	29663	66044	86849	60852
% Oligochaetes	24	34	31	31	60	58	66	61	55	74	75	68	97	78	92	87
% chironomids	69	55	62	60	36	40	33	37	29	13	23	19	3	18	8	11

Table 14: cont'd.

Station Replicate Year	0+450 Rep.1 1996	0+450 Rep.2	0+450 Rep.3	Mean	0+494 Rep.1 1995	0+494 Rep.2	0+494 Rep.3	Mean	0+565 Rep.1 1995	0+565 Rep.2	0+565 Rep.3	Mean	0+600 Rep.1 1995	0+600 Rep.2	0+600 Rep.3	Mean
PHYLUM NEMATODA	323	144	162	210												
PHYLUM ANNELIDA																
Class Oligochaeta	4718	5620	2617	4318	134500	123740	76857	111699	71239	34330	46252	50607	14057	6112	4412	8194
Class Hirudinea	97	96	194	129												
PHYLUM MOLLUSCA	65	96	0	54												
PHYLUM ARTHROPODA																
Class Malacostraca																
Order Amphipoda																
Order Isopoda	0	48	226	91									0	29	0	10
Class Insecta																
Order Coleoptera	97	0	32	43					371	0	0	124				
Order Diptera					0	0	384	128								
Athericidae	32	0	0	11												
Ceratopogonidae	65	48	129	81									0	86	0	29
Chironomidae	1034	1201	2165	1467	20848	21520	14603	18990	17068	11443	11242	13251	1041	230	65	445
Dolichopodidae																
Tabanidae																
Psychodidae																
Simuliidae																
Order Ephemeroptera	0	0	32	11												
Order Hemiptera	0	0	32	11									174	0	0	58
Order Ledidoptera																
Order Trichoptera																
Total No Organisms	6527	7349	5590	6489	155348	145260	92229	130945	89048	45943	58297	64429	15272	6456	4476	8735
% Oligochaetes	72	76	47	67	87	85	83	85	80	75	79	79	92	95	99	94
% chironomids	16	16	39	23	13	15	16	15	19	25	19	21	7	4	1	5

Table 14: cont'd.

Station	0+630E	0+630E	0+630E	Mean	0+732	0+732	0+732	Mean	0+732	0+732	0+732	Mean	0+738	0+738	0+738	Mean
Replicate	Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3	
Year	1996				1995				1996				1995			
PHYLUM NEMATODA									405	78	559	347	4702	462	3617	2927
PHYLUM ANNELIDA																
Class Oligochaeta					74207	21621	43884	46570	16342	15906	14323	15524	31466	30214	23057	28246
Class Hirudinea													0	154	904	353
PHYLUM MOLLUSCA																
PHYLUM ARTHROPODA																
Class Malacostraca																
Order Amphipoda																
Order Isopoda													181	617	226	341
Class Insecta																
Order Coleoptera	0	56	0	19									0	154	0	51
Order Diptera																
Athericidae																
Ceratopogonidae									81	78	70	76				
Chironomidae	319	167	241	242	2968	3821	10549	5780	162	156	140	152	3436	4008	8138	5794
Dolichopodidae																
Tabanidae																
Psychodidae																
Simuliidae													0	0	452	151
Order Ephemeroptera																
Order Hemiptera					371	0	0	124								
Order Ledidoptera																
Order Trichoptera																
Total No Organisms	319	222	241	261	77546	25542	54433	52507	16989	16218	15092	16100	39785	35764	36620	37390
% Oligochaetes	0	0	0	0	96	85	81	89	96	98	95	96	79	84	63	76
% chironomids	100	75	100	93	4	15	19	11	1	1	1	1	9	11	22	14

Table 14: cont'd.

Station	0+750	0+750	0+750	Mean	0+750	0+750	0+750	Mean	0+785	0+785	0+785	Mean	0+800	0+800	0+800	Mean
Replicate	Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3	
Year	1995				1996				1995				1996			
PHYLUM NEMATODA													0	0	35	12
PHYLUM ANNELIDA																
Class Oligochaeta	11956	9977	861	7598	2668	1367	1496	1844	20533	19836	22476	20948	900	258	801	653
Class Hirudinea					0	11	11	7	197	0	239	146				
PHYLUM MOLLUSCA									0	0	120	40				
PHYLUM ARTHROPODA																
Class Malacostraca																
Order Amphipoda																
Order Isopoda									1579	561	359	833				
Class Insecta																
Order Coleoptera					11	11	22	14	197	374	120	230	20	0	0	7
Order Diptera																
Athericidae																
Ceratopogonidae					0	0	11	4	197	0	0	66				
Chironomidae	6336	2739	861	3312	118	323	291	244	48963	19462	17455	28627	440	388	1184	671
Dolichopodidae																
Tabanidae																
Psychodidae																
Simuliidae									3949	13473	4782	7401	20	32	70	41
Order Ephemeroptera									0	94	0	31				
Order Hemiptera																
Order Ledidoptera	120	0	0	40												
Order Trichoptera									1382	1591	239	1071				
Total No Organisms	18412	12716	1722	10950	2798	1711	1829	2113	82131	57075	47822	62343	1440	743	2089	1424
% Oligochaetes	65	78	50	69	95	80	82	87	25	35	47	34	63	35	38	46
% chironomids	34	22	50	30	4	19	16	12	60	34	37	46	31	52	57	47

Table 14: cont'd.

Station Replicate Year	Stn 20 Rep.1 1995	Stn 20 Rep.2	Stn 20 Rep.3	Mean	Stn 21 Rep.1 1995	Stn 21 Rep.2	Stn 21 Rep.3	Mean	Stn 21P Rep.1 1996	Stn 21P Rep.2	Stn 21P Rep.3	Mean	Stn 21S Rep.1 1996	Stn 21S Rep.2	Stn 21S Rep.3	Mean
PHYLUM NEMATODA									0	154	0	51	189	0	0	63
PHYLUM ANNELIDA																
Class Oligochaeta	70401	65212	78779	71464	2389	4136	2825	3116	2935	1544	949	1809	3870	21520	1588	8992
Class Hirudinea																
PHYLUM MOLLUSCA													189	0	0	63
PHYLUM ARTHROPODA																
Class Malacostraca																
Order Amphipoda																
Order Isopoda					22	258	0	93	301	0	0	100				
Class Insecta																
Order Coleoptera	0	0	384	128	0	32	0	11	75	0	0	25				
Order Diptera																
Athericidae																
Ceratopogonidae									2182	5558	9652	5797	94	0	29	41
Chironomidae	14757	12390	26900	18016	43	323	242	203	75	0	158	78	3209	10162	2058	5143
Dolichopodidae													94	0	0	31
Tabanidae																
Psychodidae																
Simuliidae																
Order Ephemeroptera																
Order Hemiptera																
Order Ledidoptera																
Order Trichoptera	0	326	0	109												
Total No Organisms	86080	78255	106447	90261	2453	4750	3067	3423	5568	7256	10760	7861	7834	31682	3734	14417
% Oligochaetes	82	83	74	79	97	87	92	91	53	21	9	23	49	68	43	62
% chironomids	17	16	25	20	2	7	8	6	1	0	1	1	41	32	55	36

Table 14: cont'd.

Station	Stn 22	Stn 22	Stn 22	Mean	Stn 23	Stn 23	Stn 23	Mean
Replicate	Rep.1	Rep.2	Rep.3		Rep.1	Rep.2	Rep.3	
Year	1995				1995			
PHYLUM NEMATODA								
PHYLUM ANNELIDA								
Class Oligochaeta	2112	2230	2668	2337	2905	7637	10512	7018
Class Hirudinea								
PHYLUM MOLLUSCA					0	75	0	25
PHYLUM ARTHROPODA								
Class Malacostraca								
Order Amphipoda								
Order Isopoda								
Class Insecta								
Order Coleoptera	0	0	43	14	11	75	124	70
Order Diptera								
Athericidae								
Ceratopogonidae								
Chironomidae	2391	2230	2668	2430	1948	7524	5711	5061
Dolichopodidae								
Tabanidae								
Psychodidae								
Simuliidae								
Order Ephemeroptera								
Order Hemiptera					11	0	0	4
Order Ledidoptera								
Order Trichoptera								
Total No Organisms	4503	4459	5380	4781	4874	15312	16347	12178
% Oligochaetes	47	50	50	49	60	50	64	58
% chironomids	53	50	50	51	40	49	35	42

Table 15: Benthic Macroinvertabrate Taxa. Canagagigue Creek. 1995-96.
All values are in #/m^2.

Station	Stn1	0+30	0+240	0+244	0+270	0+330C	0+320	0+330W	0+345w	0+360
Replicate	Rep.2	Rep.2	Rep.3	Rep.2	Rep.1	Rep.3	Rep.3	Rep.1	Rep.2	Rep.2
Year sampled	1995	1995	1996	1995	1995	1995	1995	1995	1996	1996
PHYLUM NEMATODA						229	102	485		
PHYLUM ANNELIDA										
Class Oligochaeta										
Enchytraediae:										
fragment - simple pointed nee										
Tubificidae:										
Aulodrilus limnobius										
Aulodrilus pigueti		83								
Aulodrilus pluriseta										
Bothrioneurium vejdovskyanum		83					203	1192	100	
Branchiura sowerby			26				406	238	401	410
Ilyodrilus templetoni		83	78					238		
Limnodrilus claparedianus			26	181						
Limnodrilus hoffmeisteri	14442	83	78	181	14495	4786	203	2146	1905	3074
Limnodrilus tortilipenes										205
Limnodrilus udekemianus	601									
Limnodrilus sp.									100	
Potamothrix bavaricus					630			238		
Potamothrix moldaviensis			26							
Tubifex tubifex	601				2521	477		238	602	820
Tubifex sp.										
Immatures with hair and pectinate setae			26		3781	8134	305	715	100	205
Immatures with bifid setae	9027	165	233	90	10084	8134	812	5723	2006	5944
fragments with bifid setae	4213	83	26		630	957	102	477		
fragments with hair and bifid setae								238		
fragments with hair and pectinate setae						1434				
Naididae:										
Nais elinguis										
Nais varibilis								238		
Ophidonais serpentina	1205	83				1914		715		
Paranais frici		248								
fragments		165								
Class Hirudinea										
Erpobdellidae:										
Erpobdella punctata punctata									86	
Nephelopsis obscura									43	
Glossophoniidae:										
Placobdella montifera										
Helobdella stagnalis									43	51
juvenile glossophoniids										
PHYLLUM MOLLUSCA										
Class Bivalva									129	
Sphaeriidae:						114		97		
Musculium sp.										
Sphaerium sp.										
Class Gastropoda										
Ancylidae:										
Ferrissia rivularis										

Table 15: cont'd.

Station	Stn1	0+30	0+240	0+244	0+270	0+330C	0+320	0+330W	0+345w	0+360
Replicate	Rep.2	Rep.2	Rep.3	Rep.2	Rep.1	Rep.3	Rep.3	Rep.1	Rep.2	Rep.2
Year sampled	1995	1995	1996	1995	1995	1995	1995	1995	1996	1996
Physidae:										
Physa sp.										
Planorbidae:										
Armiger cristata										
PHYLUM ARTHROPODA										
Class Malacostraca										
Order Amphipoda										
Talitridae:										
Hyalella azteca										
Order Isopoda										
Asellidae:										
Caecidotea sp.						458		194		
Class Insecta										
Order Coleoptera										
Dytiscidae:										
Agabus sp.										
Elmidae:										
Dubiraphia sp.						114	102			
Optioservus sp.										
Stenelmis sp.										
Haliplidae:										
Haliplus sp.										
Order Diptera										
Athericidae										
Atherix sp.										
Ceratopogonidae										
Bezzia/Palpomyia sp.										
Ceratopogon sp.										
Culicoides sp.										
Chironomidae:larvae & pupae										
Tanypodinae										
Ablabesmyia sp.										
Procladius (Holotanypus) sp.			65						43	51
Procladius (Psilotanypus) sp.			22							102
Thienemannimyia group sp.										
Orthocladiinae										
Acricotopus sp.	199									
Cricotopus (Cricotopus) sp.					154				86	
Eukiefferiella sp.										
Nanocladius sp.					154	114			43	
Orthocladius sp.										
Orthocladius/Cricotopus sp.										
Thienmanniella sp.										
Chironominae										
Chironomini										
Chironomus (Camptochironomus)	1196		22	709	2152	572		1454	43	
Cladopelma sp.			108			114			172	307
Cryptochironomus sp.	199	57			154				43	51
Cryptotendipes sp.										154
Dicrotendipes sp.									86	
Einfeldia sp.									43	
Endochironomus sp.										
Glyptotendipes sp.										
Microtendipes sp.								97		

Table 15: cont'd.

Station	Stn1	0+30	0+240	0+244	0+270	0+330C	0+320	0+330W	0+345w	0+360
Replicate	Rep.2	Rep.2	Rep.3	Rep.2	Rep.1	Rep.3	Rep.3	Rep.1	Rep.2	Rep.2
Year sampled	1995	1995	1996	1995	1995	1995	1995	1995	1996	1996
Paracladopelma sp.										
Paratendipes sp.									4950	4919
Phaenopsectra sp.										
Polypedilum (Polypedilum) sp.			43						990	
Polypedilum (Tripodura) sp.				64		114			689	666
Stictochironomus sp.										
Tribelos sp.					1076	343			301	
Tanytarsini										
Cladotanytarsus sp.									43	51
Micropsectra sp.										
Paratanytarsus sp.	598			64						
Rheotanytarsus sp.										
Tanytarsus sp.			22						43	
unidentified larvae										102
Chironomidae pupae (& adults)	199	57							990	
Dolichopodidae:										
Tabanidae										
Chrysops sp.										
Psychodidae:										
Psychoda/Threttius						114				
Simuliidae:larvae & pupae										
Simulium vittatum larvae										
S. vittatum pupae										
Order Ephemeroptera									43	
Order Hemiptera										
Corixidae: nymph	199					229				
Corixa sp.										
Order Lepidoptera										
Order Trichoptera										
Hydropsychidae:										
Hydropsyche sp.										
Hydroptilidae:										
Hydroptila sp.										
Limnephilidae:										
Limnephilus sp.										
Trichoptera larvae										
Trichoptera pupae										
Total no of Organisms	32679	1187	796	1289	35831	28356	2233	14727	14124	17114
Total No of Taxa	10	8	11	5	8	14	5	13	24	14

Table 15: cont'd.

Station	0+397	0+406	0+450	0+494	0+565	0+600	0+630e	0+732	0+732	0+738
Replicate	Rep.1	Rep.2	Rep.1	Rep.2	Rep.3	Rep.2	Rep.2	Rep.3	Rep.2	Rep.2
Year sampled	1996	1995	1996	1995	1995	1995	1996	1995	1996	1995
PHYLUM NEMATODA	179		323						78	462
PHYLUM ANNELIDA										
Class Oligochaeta										
Enchytraediae:										
fragment - simple pointed nee										
Tubificidae:										
Aulodrilus limnobius										
Aulodrilus pigueti										
Aulodrilus pluriseta										
Bothrioneurium vejdovskyanum	137		92							
Branchiura sowerbyi					925	1470			300	
Ilyodrilus templetoni										
Limnodrilus claparedianus	137									
Limnodrilus hoffmeisteri	364	7039	1201	4588	4625	678		5064	4803	1233
Limnodrilus tortilipenes	137		92							
Limnodrilus udekemianus					925					
Limnodrilus sp.	46								600	
Potamothrix bavaricus	91	3017		16057	5550	781		5907	901	4316
Potamothrix moldaviensis										
Tubifex tubifex		12066		6882	6475	226		12059	5403	2466
Tubifex sp.										
Immatures with hair and pectinate setae	137	2039		64227	16651	1244		6751	600	617
Immatures with bifid setae	957	11061	2403	25232	8325	1696		8439	2101	17882
fragments with bifid setae	319	7039	924		925			2532	1201	2466
fragments with hair and bifid setae		3017		2294	925			844		617
fragments with hair and pectinate setae		1006		4588	925			1688		617
Naididae:										
Nais elinguis										
Nais variabilis										
Ophidonais serpentina										617
Paranais frici										
fragments										
Class Hirudinea										
Erpobdellidae:										
Erpobdella punctata punctata		371	32							
Nephelopsis obscura			32							
Glossophoniidae:										
Placobdella montifera										
Helobdella stagnalis	36	371	32							154
juvenile glossophoniids		1484								
PHYLLUM MOLLUSCA										
Class Bivalva										
Sphaeriidae:	72									
Musculium sp.										
Sphaerium sp.	36									
Class Gastropoda										
Ancylidae:										
Ferrissia rivularis			32							
Physidae:										
Physa sp.			32							

Table 15: cont'd.

Station	0+397	0+406	0+450	0+494	0+565	0+600	0+630e	0+732	0+732	0+738
Replicate	Rep.1	Rep.2	Rep.1	Rep.2	Rep.3	Rep.2	Rep.2	Rep.3	Rep.2	Rep.2
Year sampled	1996	1995	1996	1995	1995	1995	1996	1995	1996	1995
Planorbidae:										
Armiger cristata										
PHYLUM ARTHROPODA										
Class Malacostraca										
Order Amphipoda										
Talitridae:										
Hyalella azteca										
Order Isopoda										
Asellidae:										
Caecidotea sp.	179					29				617
Class Insecta										
Order Coleoptera										
Dytiscidae:										
Agabus sp.										154
Elmidae:										
Dubiraphia sp.			65							
Optioservus sp.										
Stenelmis sp.										
Haliplidae:										
Haliplus sp.			32				56			
Order Diptera										
Athericidae										
Atherix sp.			32							
Ceratopogonidae										
Bezzia/Palpomyia sp.										
Ceratopogon sp.	36		65			57				
Culicoides sp.						29			78	
Chironomidae:larvae & pupae										
Tanypodinae										
Ablabesmyia sp.	36									
Procladius(Holotanypus) sp.	36									
Procladius (Psilotanypus) sp.						57			78	
Thienemannimyia group sp.										
Orthocladiinae										
Acricotopus sp.		371								
Cricotopus (Cricotopus) sp.	36	1113		489	803					
Eukiefferiella sp.	36									
Nanocladius sp.			32							462
Orthocladius sp.										
Orthocladius/Cricotopus sp.		371	32			29	56			
Thienmanniella sp.										
Chironominae										
Chironomini		371		489						
Chironomus (Camptochironomus)		7421		18096	7869	29		7173		1387
Cladopelma sp.			97							
Cryptochironomus sp.	108							422		771
Cryptotendipes sp.										
Dicrotendipes sp.										
Einfeldia sp.										
Endochironomus sp.										
Glyptotendipes sp.			32	2445	2088			2743		
Microtendipes sp.										
Paracladopelma sp.										
Paratendipes sp.	646		517				56			

Table 15: cont'd.

Station	0+397	0+406	0+450	0+494	0+565	0+600	0+630e	0+732	0+732	0+738
Replicate	Rep.1	Rep.2	Rep.1	Rep.2	Rep.3	Rep.2	Rep.2	Rep.3	Rep.2	Rep.2
Year sampled	1996	1995	1996	1995	1995	1995	1996	1995	1996	1995
Phaenopsectra sp.	72	1855	97							
Polypedilum (Polypedilum) sp.	108		97			115	56			462
Polypedilum (Tripodura) sp.			97						78	
Stictochironomus sp.										
Tribelos sp.										154
Tanytarsini										
Cladotanytarsus sp.										
Micropsectra sp.			32							154
Paratanytarsus sp.										154
Rheotanytarsus sp.										308
Tanytarsus sp.										
unidentified larvae										
Chironomidae pupae (& adults)	143	371	97		803					154
Dolichopodidae:										
Tabanidae										
Chrysops sp.		371								
Psychodidae:										
Psychoda/Threttius										
Simuliidae:larvae & pupae										
Simulium vittatum larvae										
S. vittatum pupae										
Order Ephemeroptera										
Order Hemiptera										
Corixidae: nymph										
Corixa sp.										
Order Lepidoptera										
Order Trichoptera										
Hydropsychidae:										
Hydropsyche sp.										
Hydroptilidae:										
Hydroptila sp.										
Limnephilidae:										
Limnephilus sp.										
Trichoptera larvae										
Trichoptera pupae										
Total no of Organisms	4081	65751	6523	145387	57815	6449	222	54222	16222	36226
Total No of Taxa	20	13	23	7	9	11	4	6	8	17

Table 15: cont'd.

Station	0+750	0+750	0+785	0+800	Stn 20	Stn 21	Stn 21P	Stn 21S	Stn 22	Stn 23
Replicate	Rep.2	Rep.3	Rep.3	Rep.1	Rep.1	Rep.3	Rep.2	Rep.1	Rep.1	Rep.2
Year sampled	1995	1996	1995	1996	1995	1995	1996	1996	1995	1995
PHYLUM NEMATODA							154	189		
PHYLUM ANNELIDA										
Class Oligochaeta										
Enchytraediae:										
fragment - simple pointed nee				23						
Tubificidae:	196									
Aulodrilus limnobius						56				
Aulodrilus pigueti										
Aulodrilus pluriseta										599
Bothrioneurium vejdovskyanum			899		1353			94		
Branchiura sowerbyi	192	103	450	92	1353			283		
Ilyodrilus templetoni										
Limnodrilus claparedianus										299
Limnodrilus hoffmeisteri	1342	491	7192	230	9469	565		755	38	1348
Limnodrilus tortilipenes								94		
Limnodrilus udekemianus						56		661		
Limnodrilus sp.		26				56				
Potamothrix bavaricus	192	258	2697	23	9469	282				2096
Potamothrix moldaviensis										
Tubifex tubifex		465	450	23	6763			94		898
Tubifex sp.										
Immatures with hair and pectinate setae	3259	26	1798	46	12174	508	309	283	421	599
Immatures with bifid setae	4601	129	1798	69	27054	1243	772	849	1033	1647
fragments with bifid setae			899	345	2705	56	463	472	459	150
fragments with hair and bifid setae			450	23					77	
fragments with hair and pectinate setae									38	
Naididae:										
Nais elinguis								283		
Nais varibilis										
Ophidonais serpentina			5844					94		
Paranais frici										
fragments				23					38	
Class Hirudinea										
Erpobdellidae:										
Erpobdella punctata punctata										
Nephelopsis obscura			239							
Glossophoniidae:										
Placobdella montifera		11								
Helobdella stagnalis										
juvenile glossophoniids										
PHYLLUM MOLLUSCA										
Class Bivalva										
Sphaeriidae:			120					94		
Musculium sp.				20						75
Sphaerium sp.										
Class Gastropoda										
Ancylidae:										
Ferrissia rivularis										
Physidae:										
Physa sp.										

Table 15: cont'd.

Station	0+750	0+750	0+785	0+800	Stn 20	Stn 21	Stn 21P	Stn 21S	Stn 22	Stn 23
Replicate	Rep.2	Rep.3	Rep.3	Rep.1	Rep.1	Rep.3	Rep.2	Rep.1	Rep.1	Rep.2
Year sampled	1995	1996	1995	1996	1995	1995	1996	1996	1995	1995
Planorbidae:										
Armiger cristata								94		
PHYLUM ARTHROPODA										
Class Malacostraca										
Order Amphipoda										
Talitridae:										
Hyalella azteca										
Order Isopoda										
Asellidae:										
Caecidotea sp.			359							
Class Insecta										
Order Coleoptera										
Dytiscidae:										
Agabus sp.										
Elmidae:										
Dubiraphia sp.			120							75
Optioservus sp.		11		20						
Stenelmis sp.		11								
Haliplidae:										
Haliplus sp.										
Order Diptera										
Athericidae										
Atherix sp.										
Ceratopogonidae										
Bezzia/Palpomyia sp.										
Ceratopogon sp.		11								
Culicoides sp.							5558	94		
Chironomidae:larvae & pupae										
Tanypodinae										38
Ablabesmyia sp.										
Procladius(Holotanypus) sp.		11								
Procladius (Psilotanypus) sp.		22								
Thienemannimyia group sp.			239							
Orthocladiinae										
Acricotopus sp.					307					
Cricotopus (Cricotopus) sp.	196		5978							
Eukiefferiella sp.										
Nanocladius sp.				60						
Orthocladius sp.										
Orthocladius/Cricotopus sp.	98		3108	40						
Thienmanniella sp.			239	20						
Chironominae										
Chironomini	196		239							
Chironomus (Camptochironomus)	1956	22			12297	242			2272	6923
Cladopelma sp.		22								
Cryptochironomus sp.									80	113
Cryptotendipes sp.										
Dicrotendipes sp.										
Einfeldia sp.					307					
Endochironomus sp.					615					
Glyptotendipes sp.	293		478		307					
Microtendipes sp.			120	20						
Paracladopelma sp.										113
Paratendipes sp.		118		60				2265		

Table 15: cont'd.

Station	0+750	0+750	0+785	0+800	Stn 20	Stn 21	Stn 21P	Stn 21S	Stn 22	Stn 23
Replicate	Rep.2	Rep.3	Rep.3	Rep.1	Rep.1	Rep.3	Rep.2	Rep.1	Rep.1	Rep.2
Year sampled	1995	1996	1995	1996	1995	1995	1996	1996	1995	1995
Phaenopsectra sp.		43	598					283	40	
Polypedilum (Polypedilum) sp.			837	120						
Polypedilum (Tripodura) sp.				60				472		
Stictochironomus sp.										75
Tribelos sp.										
Tanytarsini										
Cladotanytarsus sp.										
Micropsectra sp.										
Paratanytarsus sp.			359							
Rheotanytarsus sp.			1076							
Tanytarsus sp.										150
unidentified larvae		11								
Chironomidae pupae (& adults)			2032	60	922			189		
Dolichopodidae:								94		
Tabanidae										
Chrysops sp.										
Psychodidae:										
Psychoda/Threttius										
Simuliidae:larvae & pupae										
Simulium vittatum larvae										
S. vittatum pupae										
Order Ephemeroptera										
Order Hemiptera										
Corixidae: nymph										
Corixa sp.										
Order Lepidoptera										
Order Trichoptera										
Hydropsychidae:										
Hydropsyche sp.			120							
Hydroptilidae:										
Hydroptila sp.			120							
Limnephilidae:										
Limnephilus sp.		11								
Trichoptera larvae										
Trichoptera pupae										
Total no of Organisms	12709	1799	38856	1377	85096	3067	7256	7740	4495	12199
Total No of Taxa	7	16	22	15	9	6	2	14	4	13

Table 16: Dioxin and Furan Concentrations in Sediments and In-situ Biota. Canagagigue Creek. 1996 (All values in pg/g (ppt)). Concentrations listed are totals for each congener group.

Station		T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
Sediment																			
0+30		7.9	I5	4.3	I2	8.8	I3	1	<	9.4	I3	9.7	I5	26	I2	43	I2	26	150
Biota																			
0+30	Wet weight	1	<	2	<	1	<	1	<	1	<	1	<	1	<	1	<	1<	2<
	Dry weight	1	<	2	<	1	<	1	<	1	<	1	<	1	<	1	<	1<	2<
Sediment																			
0+565		89	I7	26	I4	39	I4	1.8	I1	40	I6	18	I5	98	I2	66	I2	120	250
Biota																			
0+565	Wet weight	29	I6	4.8	I2	1.6	I1	1	<	3.8	I2	1	<	19	I2	9.4	I2	24	27
	Dry weight	182		30		10				24				119		59		151	170
Sediment																			
0+750	(mean 1995-96)	363		107		126		28		177		54		857		233		1167	893
Biota																			
0+750	Wet weight	88	I6	13	I3	5.4	I2	1.4	I1	4.8	I3	1	<	16	I2	3.6	I2	18	12
	Dry weight	553		81		34		9		30				101		23		113	76

I + number - Isomers, number detected < - Below detection limit

Table 16: cont'd. Concentrations listed are for 2,3,7,8-substituted isomers (pg/g dry weight).

2,3,7,8-substituted isomers		2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	1,2,3,4,7,8-H_6CDF	1,2,3,6,7,8-H_6CDF	2,3,4,6,7,8-H_6CDF	1,2,3,7,8,9-H_6CDF	1,2,3,4,7,8-H_6CDF
I-TEF		*0.1*	*1*	*0.05*	*0.5*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Sediment											
0+30		1.3	1<	1<	1<	1<	1<	1<	1<	1<	1<
Biote											
0+30	Wet weight	1<	1<	1<	1<	1<	1<	1<	1<	1<	1<
	Dry weight	1<	1<	1<	1<	1<	1<	1<	1<	1<	1<
Sediment											
0+565		15	14	1<	1.5	1<	2.3	1.4	2.9	1<	1<
Biote											
0+565	Wet weight	3.4	2.5	1<	1<	1<	1<	1<	1<	1<	1<
	Dry weight	21	16								
Sediment											
0+750 (mean 1995-96)		47	60	3.0	3.6	4.8	5.0	4.0	5.9	1<	1.8
Biote											
0+750	Wet weight	10	9.7	1<	1<	1<	1<	1<	1<	1<	1<
	Dry weight	63	61								

< - Below detection limit

Table 16: cont'd.

2,3,7,8-substituted isomers		1,2,3,6,7,8-H_6CDD	1,2,3,7,8,9-H_6CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF		*0.1*	*0.1*	*0.01*	*0.01*	*0.01*	*0.001*	*0.001*	
Sediment									
0+30		1.3	1.3	9.8	1<	25	26	150	0.9
Biota									
0+30	Wet weight	1<	1<	1<	1<	1<	1<	2<	<
	Dry weight	1<	1<	1<	1<	1<	1<	2<	<
Sediment									
0+565		2.8	1.8	42	1<	36	120	250	18.5
Biota									
0+565	Wet weight	1<	1<	7.7	1<	3.2	24	27	3.0
	Dry weight			48		20	151	170	19.1
Sediment									
0+750 (mean 1995-96)		10.8	4.3	337	4.6	139	1167	893	
Biota									
0+750	Wet weight	1<	1<	6.4	1<	2.2	18	12	10.8
	Dry weight			40		14	113	76	68.0

< - Below detection limit

TABLE 17. Mean (± s.d.) water quality characteristics in sediment bioassays.

Test Organism: Mayfly (Hexagenia limbata)[a] Test Temperature: 18.3°C (0.7)

Station	*pH*	*D.O.* mg/L	*Conductivity* umho/cm	*Total Ammonia* mg/L	*Un–ionized Ammonia* mg/L
Control	7.97 (.08)	8.7 (0.2)	286 (7)	<0.10	<0.003
Reference (0+30)	8.37 (.08)	8.5 (0.2)	444 (64)	0.77 (1.35)	0.058
Stn 0+244	8.23 (.16)	7.8 (1.0)	517 (81)	1.11 (1.92)	0.045
Stn 0+630W	8.39 (.02)	8.8 (0.1)	505 (82)	3.00 (1.41)	0.222
Stn 0+750	8.42 (.04)	8.6 (0.1)	691 (67)	2.55 (2.94)	0.244
Stn 21–S	8.29 (.03)	8.2 (0.5)	457 (35)	0.70 (1.12)	0.052
Stn FP–3	8.32 (.04)	8.5 (0.2)	522 (142)	0.42 (0.64)	0.031

Test Organism: Midge (Chironomus tentans)[b] Test Temperature: 20.0°C (0.9)

Station	*pH*	*D.O.* mg/L	*Conductivity* umho/cm	*Total Ammonia* mg/L	*Un–ionized Ammonia* mg/L
Control	8.12 (.08)	8.4 (0.4)	301 (1)	0.10 (0.01)	0.005
Reference (0+30)	8.31 (.11)	7.9 (0.6)	418 (48)	0.90 (1.38)	0.039
Stn 0+244	8.25 (.12)	7.5 (0.6)	475 (53)	1.45 (1.27)	0.138
Stn 0+630W	8.09 (.24)	6.8 (1.6)	532 (66)	3.83 (1.25)	0.186
Stn 0+750	8.42 (.09)	8.0 (0.3)	699 (99)	6.86 (2.51)	0.815
Stn 21–S	8.37 (.18)	7.8 (0.4)	457 (44)	1.10 (1.04)	0.098
Stn FP–3	8.25 (.09)	7.8 (0.7)	425 (30)	0.94 (0.84)	0.068

Test Organism: Minnow (Pimephales promelas)[a] Test Temperature: 19.4°C (1.1)

Station	*pH*	*D.O.* mg/L	*Conductivity* umho/cm	*Total Ammonia* mg/L	*Un–ionized Ammonia* mg/L
Control	7.37 (.58)	8.1 (0.4)	326 (25)	0.77 (0.53)	0.013
Reference (0+30)	8.00 (.09)	8.1 (0.3)	442 (67)	2.55 (3.48)	0.097
Stn 0+244	8.00 (.15)	8.0 (0.4)	461 (36)	2.57 (3.27)	0.088
Stn 0+630W	8.46 (.08)	8.2 (0.4)	598 (111)	13.33 (5.50)	1.580
Stn 0+750	8.11 (.17)	8.1 (0.3)	786 (123)	10.40 (9.33)	0.637
Stn 21–S	8.02 (.21)	7.8 (0.3)	472 (56)	1.95 (2.35)	0.066
Stn FP–3	7.82 (.03)	7.9 (0.3)	578 (135)	2.75 (3.25)	0.095

a Sample size N=4; b Sample size N=3.

Underlining indicates un–ionized ammonia concentrations that exceed the PWQO of 0.02 mg/L.

TABLE 18. Sediment physical and nutrient characteristics in bioassay sediments.

Station	*% Sand* (2mm–62um)	*% Silt* (62–3.7um)	*% Clay* (3.7–0.1um)	*% LOI*	*TOC* mg/g	*TP* mg/g	*TKN* mg/g
Georgian Bay Control	4.0	70.6	25.7	5.3	22	0.9	1.9
Reference Station 0+30	8.0	60.1	31.5	5.6	24	1.1	1.8
Canagagique Station 0+244	22.9	54.5	22.9	5.0	25	1.1	2.0
Station 0+630W	60.4	27.3	30.2	6.1	31	0.8	1.7
Station 0+750	10.1	59.1	30.2	6.1	31	0.8	1.7
Station 21–S	24.6	52.6	23.0	2.9	17	0.8	0.8
Station FP–3	9.0	65.1	25.8	9.0	40	1.2	3.0
PSQG SEL Conc (mg/g dry weight)					100	2.0	4.8

TABLE 19. Bulk concentrations of trace metals in bioassay sediments (μg/g dry weight).

Station	*Al %*	*As*	*Cd*	*Cr*	*Cu*	*Fe %*	*Hg*	*Mn*	*Ni*	*Pb*	*Zn*
Georgian Bay Control	1.4	4.1	0.3 <T	29	15	2.5	0.06	690	21	58	89
Reference Station 0+30	1.4	4.2	0.6 <T	23	19	1.8	0.05	600	14	21	97
Canagagique Station 0+244	0.9	3.4	0.4 <T	18	24	1.5	0.05	490	12	12	82
Station 0+630W	0.3	1.4	0.3 <T	10	15	0.8	0.04 <T	260	5.1	18	46
Station 0+750	0.8	4.8	0.7 <T	18	45	1.4	0.17	370	13	34	140
Station 21–S	0.7	2.4	0.2 <W	13	13	1.2	0.05	420	7.8	10	60
Station FP–3	1.4	3.9	0.6 <T	22	23	1.8	0.09	480	15	18	110
PSQG LEL Conc.	NA	33	10	110	110	4.0	2.0	1100	75	250	820
PSQG SEL Conc.	NA	6.0	0.6	26	16	2.0	0.20	460	16	31	120

<W – Not Detected; <T – Trace Amount; NA – Not Available.

Underlining indicate sediment trace metal concentrations that exceed PSQG–LELs.

TABLE 20. Concentrations of selected organic compounds in bioassay sediments.

Station	Total PCBs (ng/g)	pp–DDE (ng/g)	op–DDT (ng/g)	pp–DDD (ng/g)	pp–DDT (ng/g)	g–BHC (ng/g)	Total 2378–TetraCDD TEQ (pg/g)
Georgian Bay Control	20 <W	2 <T	5 <W	5 <W	5 <W	1 <W	Not Measured
Reference Station 0+30	20 <W	3 <T	5 <W	5 <W	5 <W	1 <W	0.73
Canagagique Station 0+244	20 <W	58	35 <T	35	140	1 <W	Not Measured
Station 0+630W	20 <W	55	30 <T	6000	85	17	Not Measured
Station 0+750	20 <W	1 <W	50	520	35 <T	29	200.19
Station 21–S	20 <W	84	10 <T	50	860	1 <W	Not Measured
Station FP–3	20 <W	1 <W	5 <W	40 <T	5 <W	1 <W	23.22

All concentrations reported as dry weight; < W – Not Detected; < T – Trace Amount.

Shading indicates sediment organic concentrations that exceed PSQG–SELs.

Underlining indicates sediment organic concentrations that exceed PSQG–LELs.

Compounds measured at non–detect concentrations included: heptachlor, aldrin, mirex, a–&b–BHC, a–&g–chlordane, oxychlordane, methoxychlor, endosulphan, dieldrin, endrin, chlorinated benzenes and toluenes, hexachloroethane, heptachlor epoxide, endosulphan sulphate, octachlorostyrene, hexachlorobutadiene and dichlorobenzly chloride.

TABLE 21. Summary of biological results on mayfly, midge and minnow sediment bioassays.
Mean values (± standard deviation).

Test Organism	*Hexagenia limbata* (Mayfly)		*Chironomus tentans* (Midge)		*Pimephales promelas* (Fathead Minnow)
Station	*% Mortality* (N=3)	*Ave. Individual Body Weight* (mg wet wt.)	*% Mortality* (N=3)	*Ave. Individual Body Weight* (mg wet wt.)	*% Mortality* (N=3)
Georgian Bay Control	A 0 (0)	B 6.20 (0.5)	A 2.2 (4)	C 12.78 (2.0)	A 0 (0)
Reference Station 0+30	A 0 (0)	A 36.25 (3.3)	A 11.1 (10)	B 15.95 (0.4)	A 3.3 (6)
Canagagique Station 0+244	A 0 (0)	A 33.71 (1.8)	A 11.1 (19)	A 19.64 (1.7)	A 0 (0)
Station 0+630W	C ** 100 (0)	–	C ** 93.3 (7)	–	C ** 100 (0)
Station 0+750	B ** 50.0 (20)	B 5.89 (0.3)	B ** 51.1 (10)	D 9.65 (2.0)	B ** 20.0 (17)
Station 21–S	A 0 (0)	A 36.91 (2.7)	AB 13.2 (11)	AB 16.95 (0.3)	A 0 (0)
Station FP–3	A 0 (0)	A 35.70 (1.7)	A 2.2 (4)	AB 18.39 (1.4)	A 0 (0)
% MSD	15.6	–	21.9	–	14.2
% C.V.	13.3	8.6	35.3	8.4	18.6
D.P.	35.0	17.8	9.7	7.5	30.4

** %Mortality value is significantly different than the control and reference sediment (Dunnett's t–test;$p<0.05$).

A Means sharing a common letter within a column are not significantly different; Tukey's HSD test for % Mortality ($p<0.05$) and planned comparisons using LSMEANS for comparing Body Weight ($p<0.01$).

MSD – Minimum Significant Difference; C.V. – Coefficient of Variation; D.P. – Discriminatory Power.

Table 22a: Dioxin and Furan Concentrations in Bioassay Sediments and Fathead Minnows. Canagagigue Creek. 1996 (All values in pg/g (ppt)). Concentrations listed are totals for each congener group.

Congener groups	T_4CDF		T_4CDD		P_5CDF		P_5CDD		H_6CDF		H_6CDD		H_7CDF		H_7CDD		O_8CDF	O_8CDD
Station 0+30																		
Sediment	7.5	I8	1.5	I1	7.3	I2	1.0	I1	8.2	I4	8.9	I4	15	I2	37	I2	13	110
Minnow B Wet weight	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0<	2.0<
Dry weight																		
Station 0+750																		
Sediment	450	I10	200	I5	200	I8	24	I5	530	I8	110	I6	4300	I3	790	I2	5800	3300
Minnow Wet weight	1.0	<	17	I1	1.0	<	1.0	<	2.6	I1	1.0	<	17	I2	2.0	<	26	7.0<
Dry weight			107						16				107				164	
Station FP-3																		
Sediment	150	I6	59	I4	62	I3	14	I5	61	I7	32	I5	250	I3	92	I3	240	440
Minnow A Wet weight	1.0	<	3.1	I1	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	2.0<	4.0<
Dry weight			20															
Minnow B Wet weight	1.0	<	3.0	I1	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	3.0<	7.0<
Dry weight			19															
Station 21-S																		
Sediment																		
Minnow A Wet weight	1.0	<	3.0	I1	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	3.0<	4.0<
Dry weight			19															
Minnow B Wet weight	1.3	I1	4.3	I1	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	1.0	<	2.0<	5.0<
Dry weight	8.2		27															

I=Total number of isomers detected

able 22a: cont'd. Concentrations of 2,3,7,8-substituted isomers in bioassay sediments and fathead minnow tissues.
All sediment values are in pg/g dry weight.

3,7,8-substituted omers		2,3,7,8-T_4CDF	2,3,7,8-T_4CDD	1,2,3,7,8-P_5CDF	2,3,4,7,8-P_5CDF	1,2,3,7,8-P_5CDD	1,2,3,4,7,8-H_6CDF	1,2,3,6,7,8-H_6CDF	2,3,4,6,7,8-H_6CDF	1,2,3,7,8,9-H_6CDF	1,2,3,4,7,8-H_6CDF
TEF		*0.1*	*1*	*0.05*	*0.5*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
ation 0+30											
diment		1.5	1.0<	1.0<	1.0<	1.0<	1.1	1.0<	1.0<	1.0<	1.0<
innow B	Wet weight	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<
	Dry weight										
ation 0+750											
diment		87	150	1.2	2.4	5.8	7.0	6.1	11	1.0	3.9
innow	Wet weight	1.0<	17	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<
	Dry weight		107								
ation FP-3											
diment		17	17	1.0<	1.0<	1.4	2.6	3.0	2.1	1.0<	1.0<
nnow A	Wet weight	1.0<	3.1	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<
	Dry weight		20								
nnow B	Wet weight	1.0<	3.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<
	Dry weight										
ation 21-S											
diment											
nnow A	Wet weight	1.0<	3.5	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<
	Dry weight		22								
nnow B	Wet weight	1.0<	4.3	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<
	Dry weight		27								

Table 22a: cont'd.

2,3,7,8-substituted isomers		1,2,3,6,7,8-H_6CDD	1,2,3,7,8,9-H_6CDD	1,2,3,4,6,7,8-H_7CDF	1,2,3,4,7,8,9-H_7CDF	1,2,3,4,6,7,8-H_7CDD	O_8CDF	O_8CDD	Total TEQ
I-TEF		*0.1*	*0.1*	*0.01*	*0.01*	*0.01*	*0.001*	*0.001*	
Station 0+30									
Sediment		1.0<	1.1	6.6	1.0<	18	13	110	0.63
Minnow B	Wet weight	1.0<	1.0<	1.0<	1.0<	1.0<	1.0<	2.0<	
	Dry weight								
Station 0+750									
Sediment		25	8.4	1700	19	490	5800	3300	200.3
Minnow	Wet weight	1.0<	1.0<	8.0	1.0<	2.0<	26	7.0<	
	Dry weight			50			164		107.7
Station FP-3									
Sediment		3.8	2.7	120	1.8	51	240	440	23.2
Minnow A	Wet weight	1.0<	1.0<	1.0<	1.0<	1.0<	2.0<	4.0<	
	Dry weight								20
Minnow B	Wet weight	1.0<	1.0<	1.0<	1.0<	1.0<	3.0<	7.0<	
	Dry weight								
Station 21-S									
Sediment									
Minnow A	Wet weight	1.0<	1.0<	1.0<	1.0<	1.0<	3.0<	4.0<	
	Dry weight								22
Minnow B	Wet weight	1.0<	1.0<	1.0<	1.0<	1.0<	2.0<	5.0<	
	Dry weight								27

< - below detection limit

Table 22b: DDT and Metabolite Concentrations in Bioassay Sediments and Fathead Minnows. Canagagigue Creek. 1996.

All values in ng/g (ppb). Sediment concentrations in dry weight.

			pp-DDE	pp-DDD	op-DDT	pp-DDT
Pre Exposure	Sediment					
	Minnow A	wet weight	1<W	5<W	5<W	5<W
	Minnow B	wet weight	3<T	5<W	5<W	5<W
	Minnow B	dry weight	18.9<T			
Control Georgian Bay	Sediment		2<T	5<W	5<W	5<W
	Minnow A	wet weight	1<W	5<W	5<W	5<W
	Minnow B	wet weight	1<W	5<W	5<W	5<W
	Minnow B	dry weight				
0+30	Sediment		3<T	5<W	5<W	5<W
	Minnow B	wet weight	5<T	5<W	5<W	5<W
	Minnow B	dry weight	31.5<T			
0+244	Sediment		58	35	35<T	140
	Minnow A	wet weight	79	35<T	10<T	10<T
	Minnow A	dry weight	498	221<T	63<T	63<T
	Minnow B	wet weight	86	45<T	15<T	20<T
	Minnow B	dry weight	542	284<T	95<T	126<T
0+750	Sediment		1<W	520	50	35<T
	Minnow A	wet weight	25	85	5<W	5<W
	Minnow A	dry weight	158	536		

TABLE 23. Spearman rank correlation coefficients for toxicity data.

	Mayfly Survival	Mayfly Growth	Midge Survival	Midge Growth
Mayfly Growth	+ .845 **			
Midge Survival	+ .857 **	n.s.		
Midge Growth	+ .845 **	n.s.	+ .811 *	
Minnow Survival	+ .898 **	n.s.	+ .770 *	+ .941 **

** $p < 0.05$; * $p < 0.10$; n.s. – Not Significant at $p=0.10$.

TABLE 24. Summary of correlation (Spearman Rank) analysis on bioassay sediments.

Toxicity Endpoint	Mayfly Survival	Mayfly Growth	Midge Survival	Midge Growth	Minnow Survival
Bulk Concentration			+ Al ** + Cr * + Fe ** + Ni *		
	– pp–DDD ** – g–BHC **	– g–BHC *	– pp–DDD * – g–BHC *	– g–BHC *	– g–BHC *
TOC corrected[a] Concentration	– Hg ** – Zn **		– Hg * – Zn **	– Hg * – Zn **	– Zn **
%Fines corrected[b] Concentration			+ Al ** + Ni *		

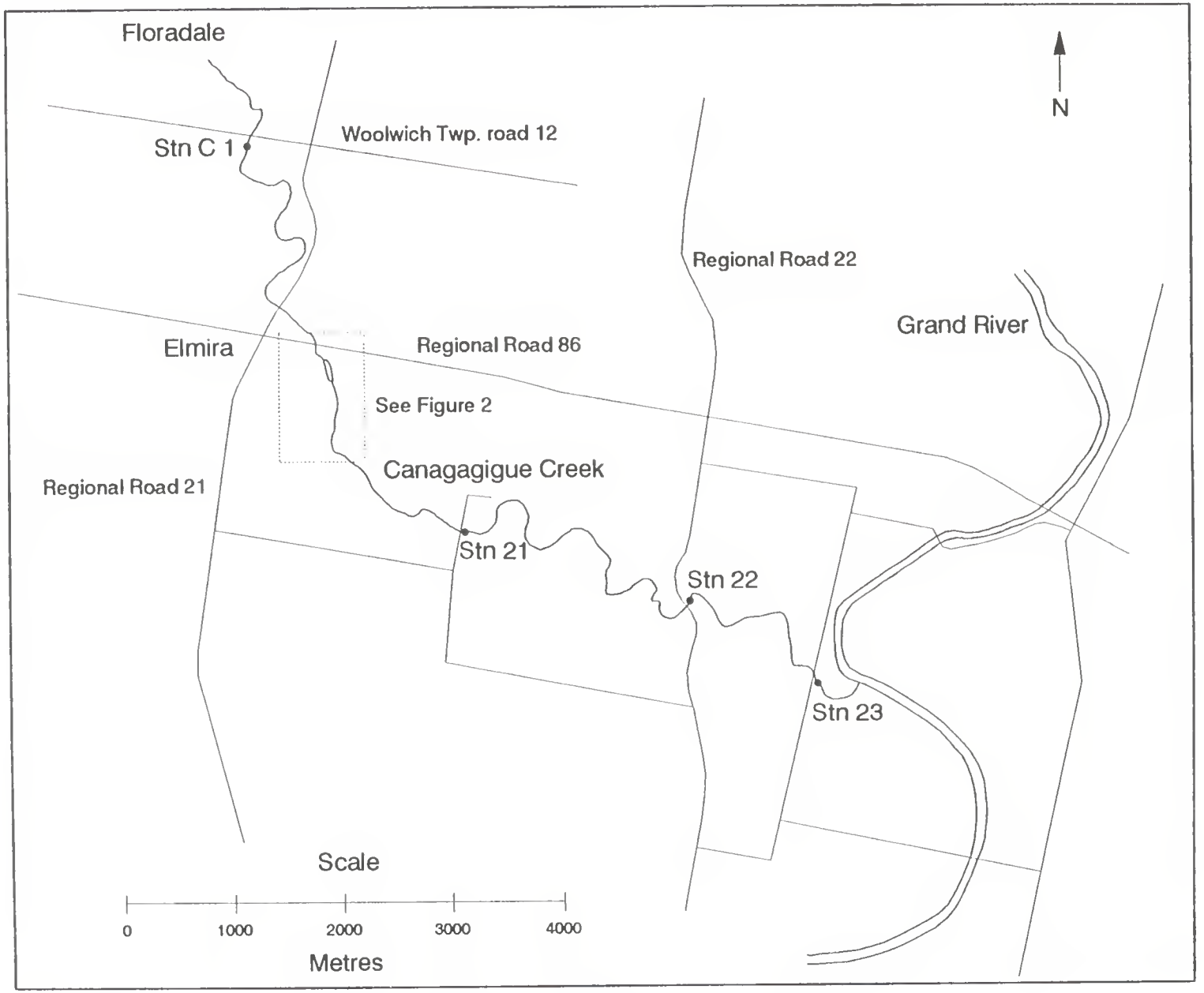
a Included Hg, Ni and Zn.

b Included Al, As, Cr, Fe, Ni, DDT and op + pp DDT.

** $p < 0.05$; * $p < 0.10$; + sign indicates a positive (direct) correlation and a – sign indicates a negative (inverse) correlation.

Figures

Figure 1: Map of Study Area



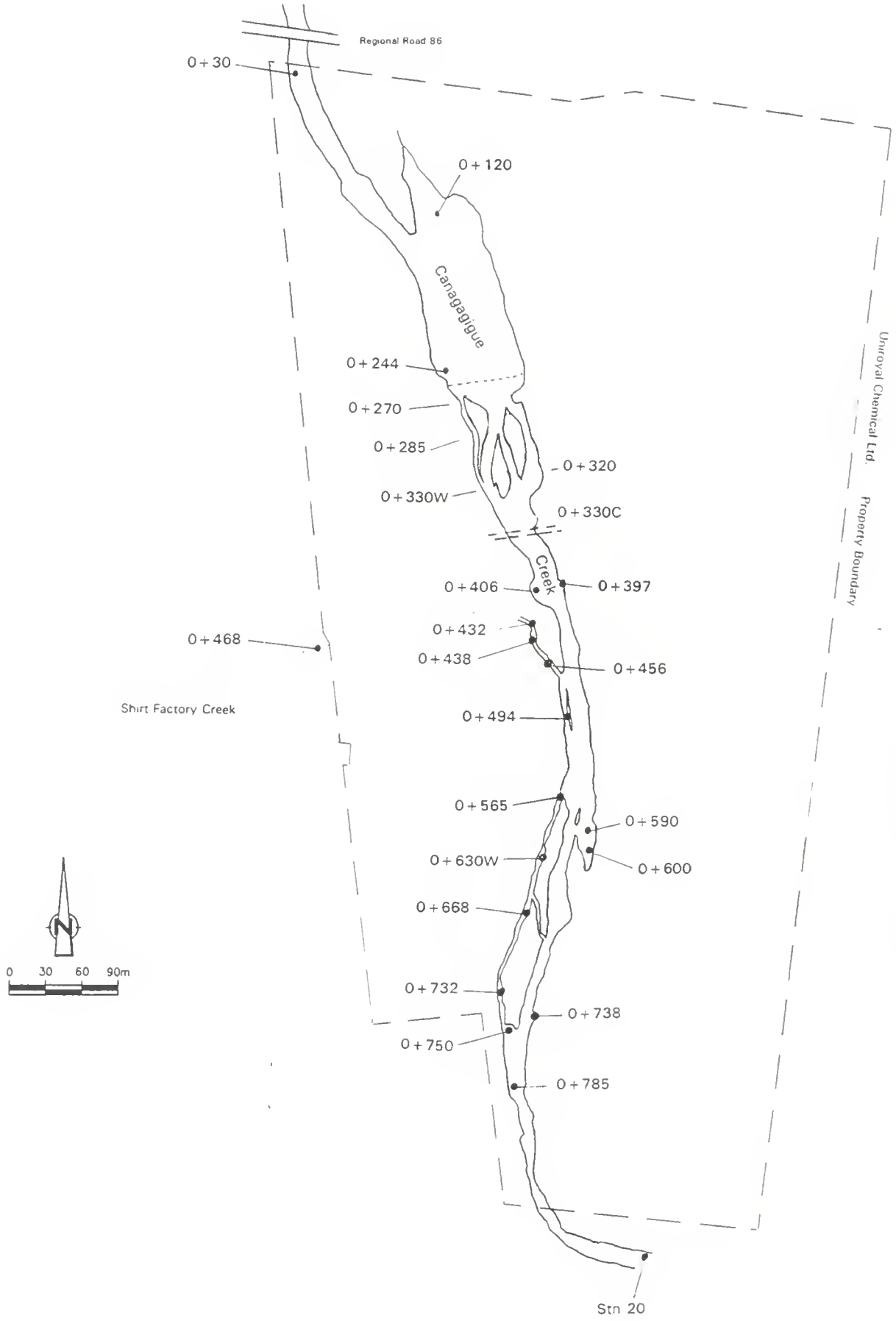


Figure 2: Detail of Sediment Sampling Locations. 1995

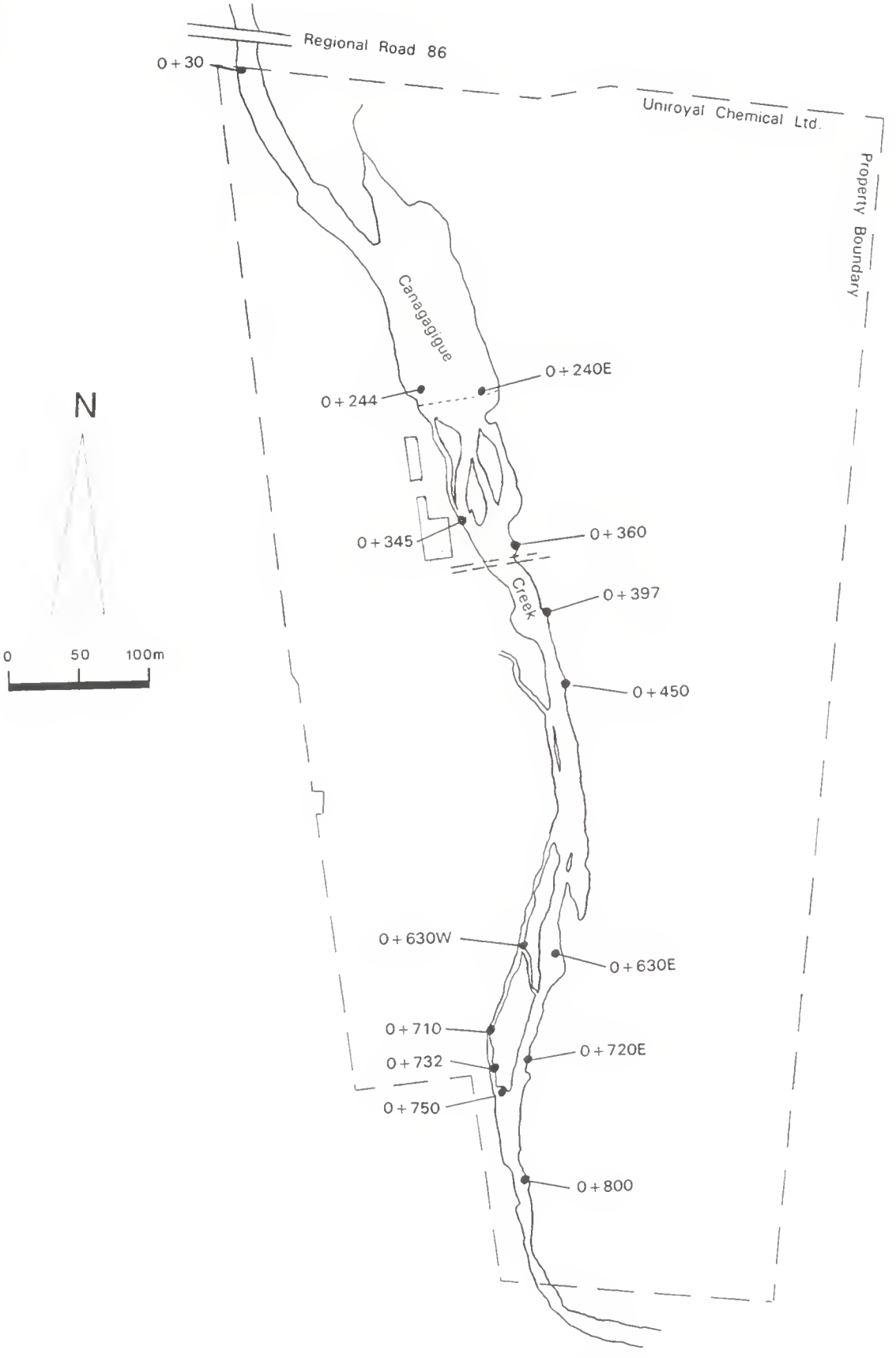


Figure 3 : Detail of Sediment Sampling Locations. 1996

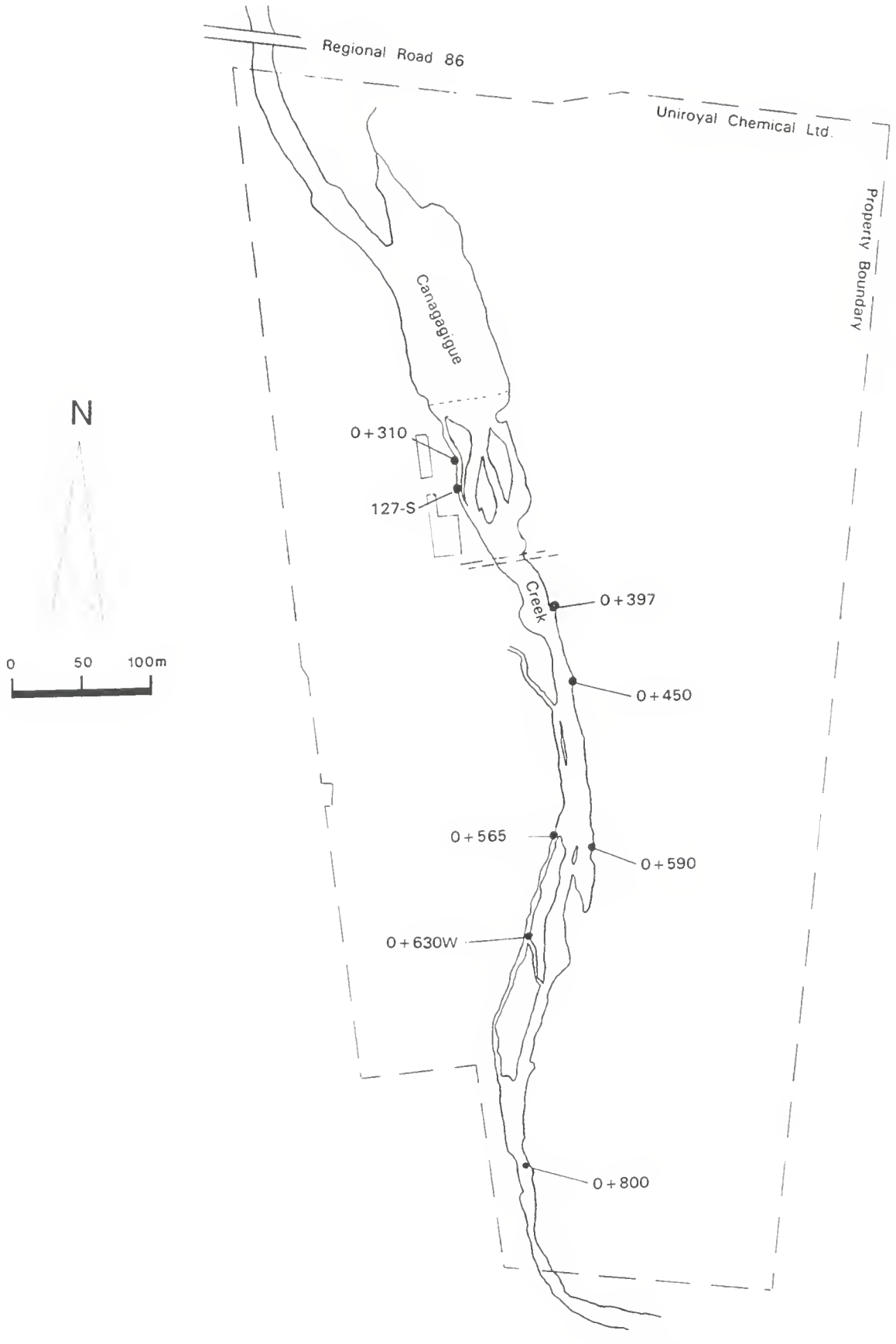
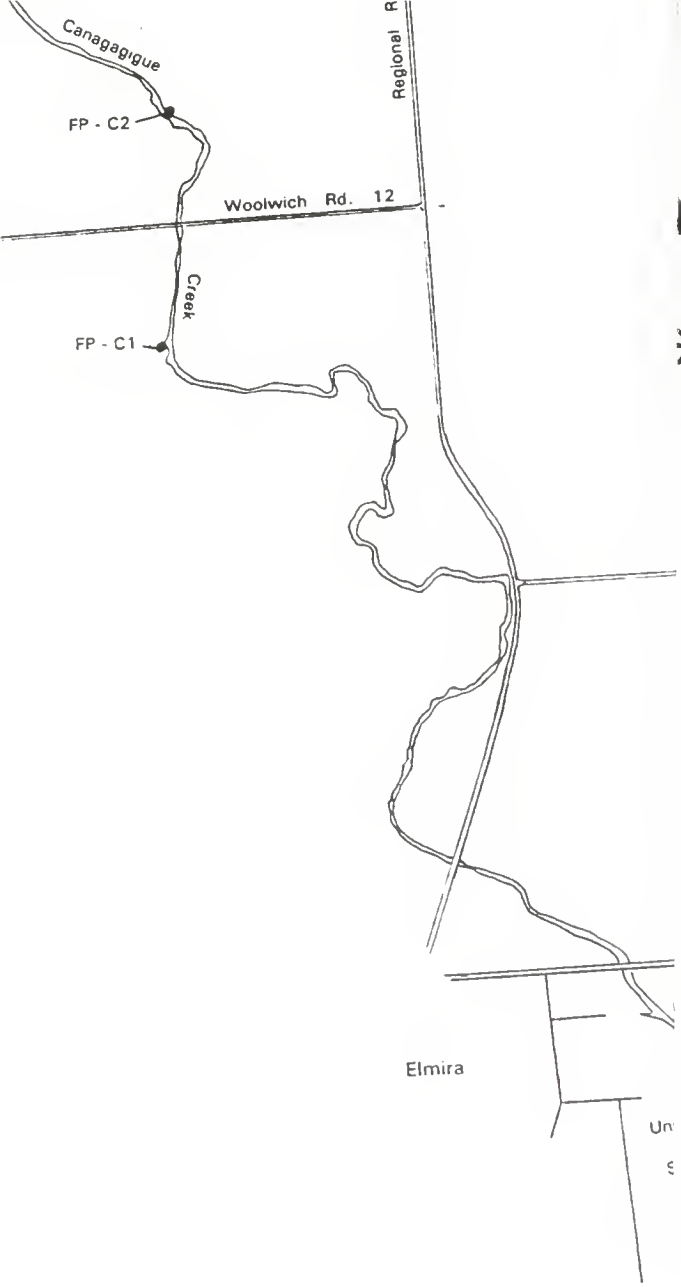


Figure 4 : Detail of Stream Bank Sampling Locations. 1996



npling Sites

er, 1996.

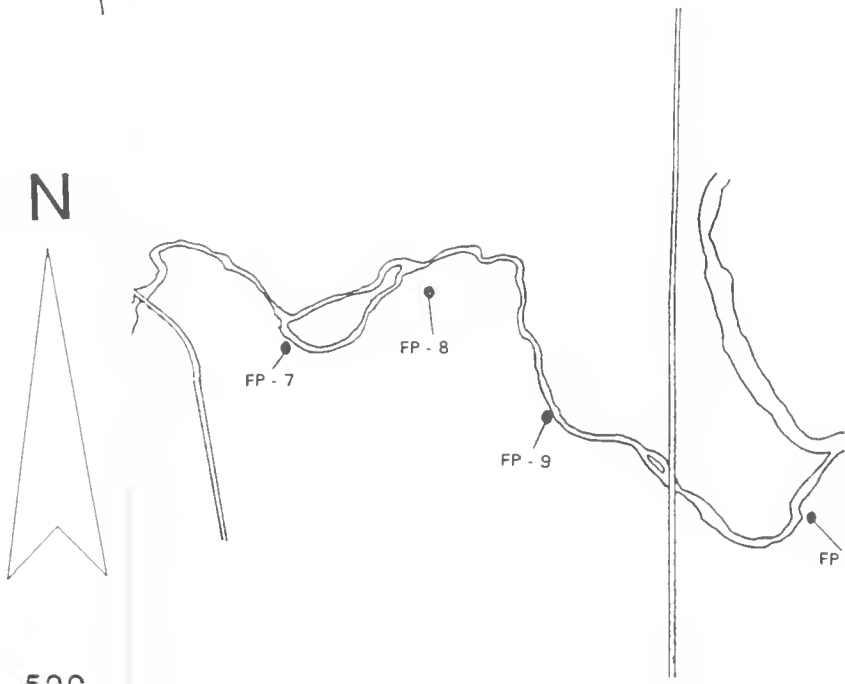
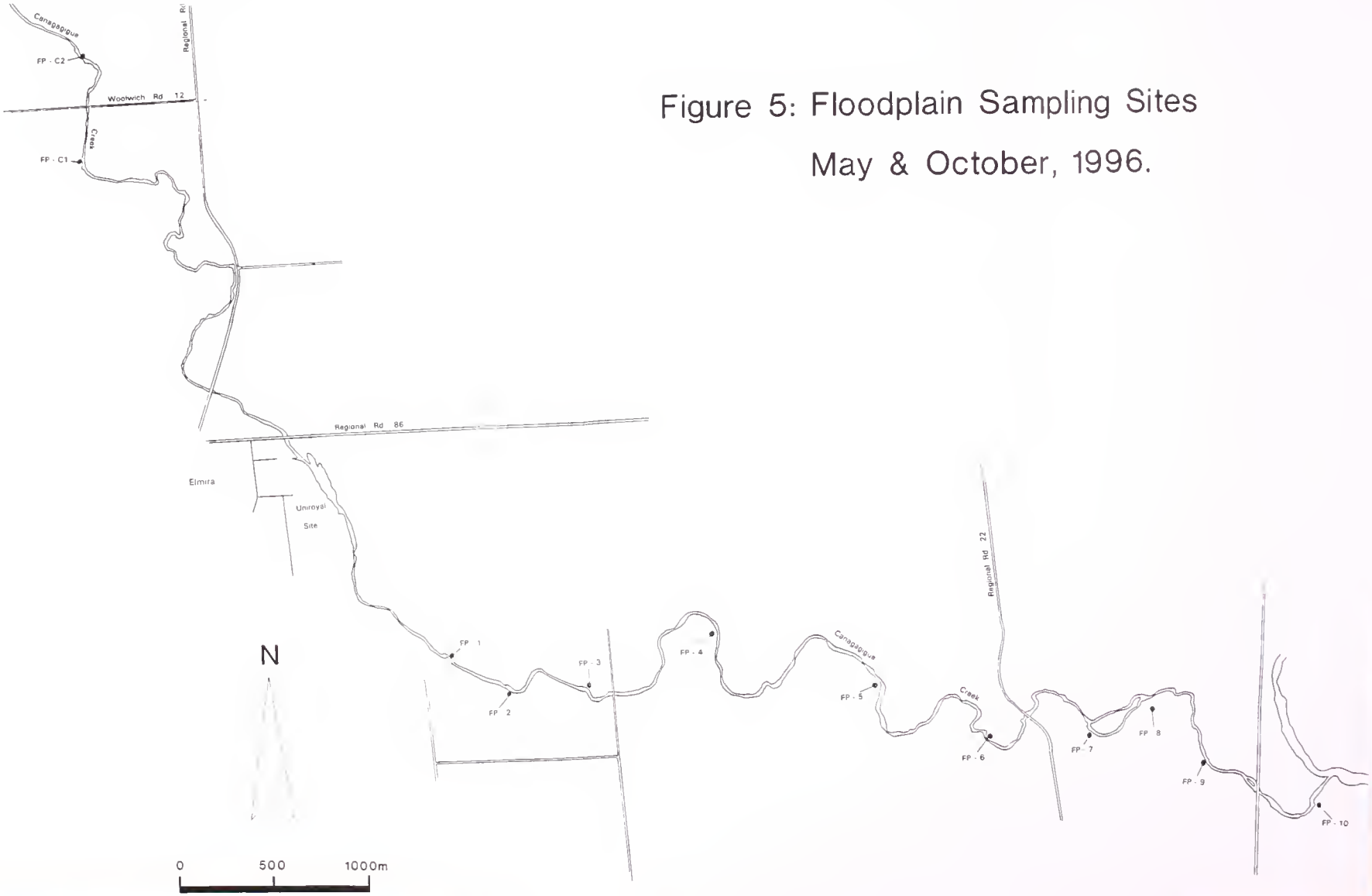


Figure 5: Floodplain Sampling Sites

May & October, 1996.



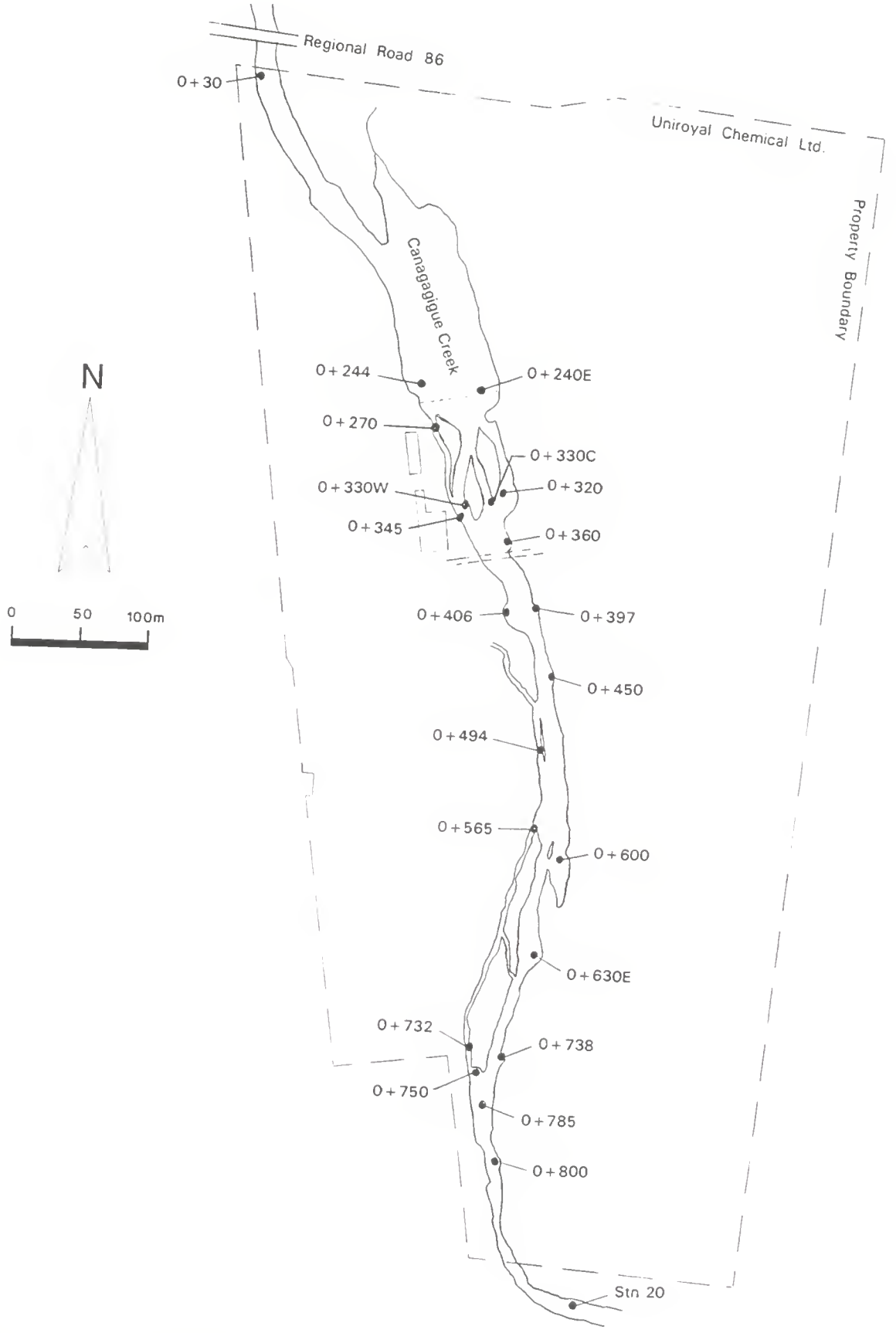


Figure 6 : Detail of Benthic Sampling Locations. 1995-96

Figure 7: DDT and Metabolites in Surficial Sediments

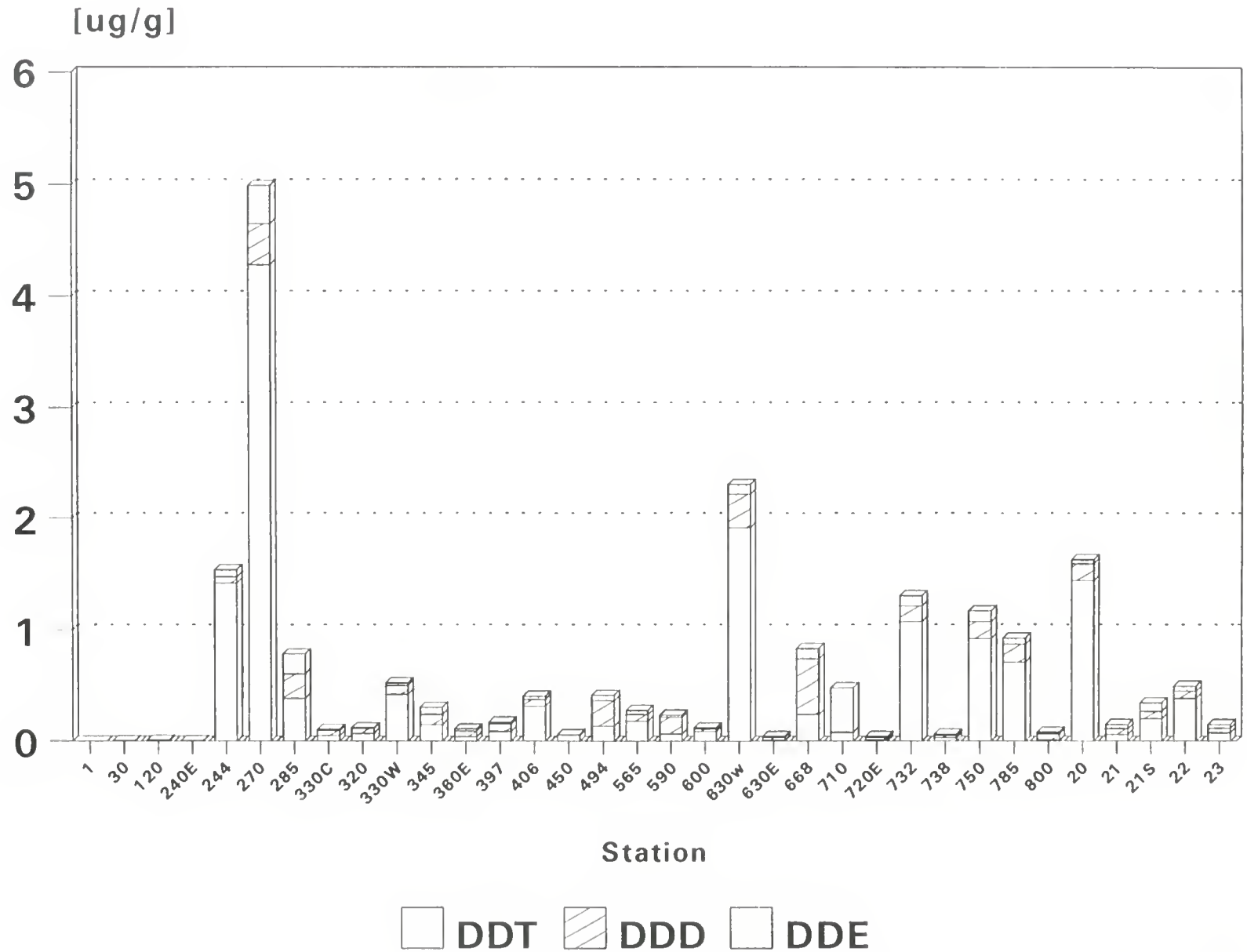


Figure 8: 2,3,7,8-TCDD in Surficial Sediments

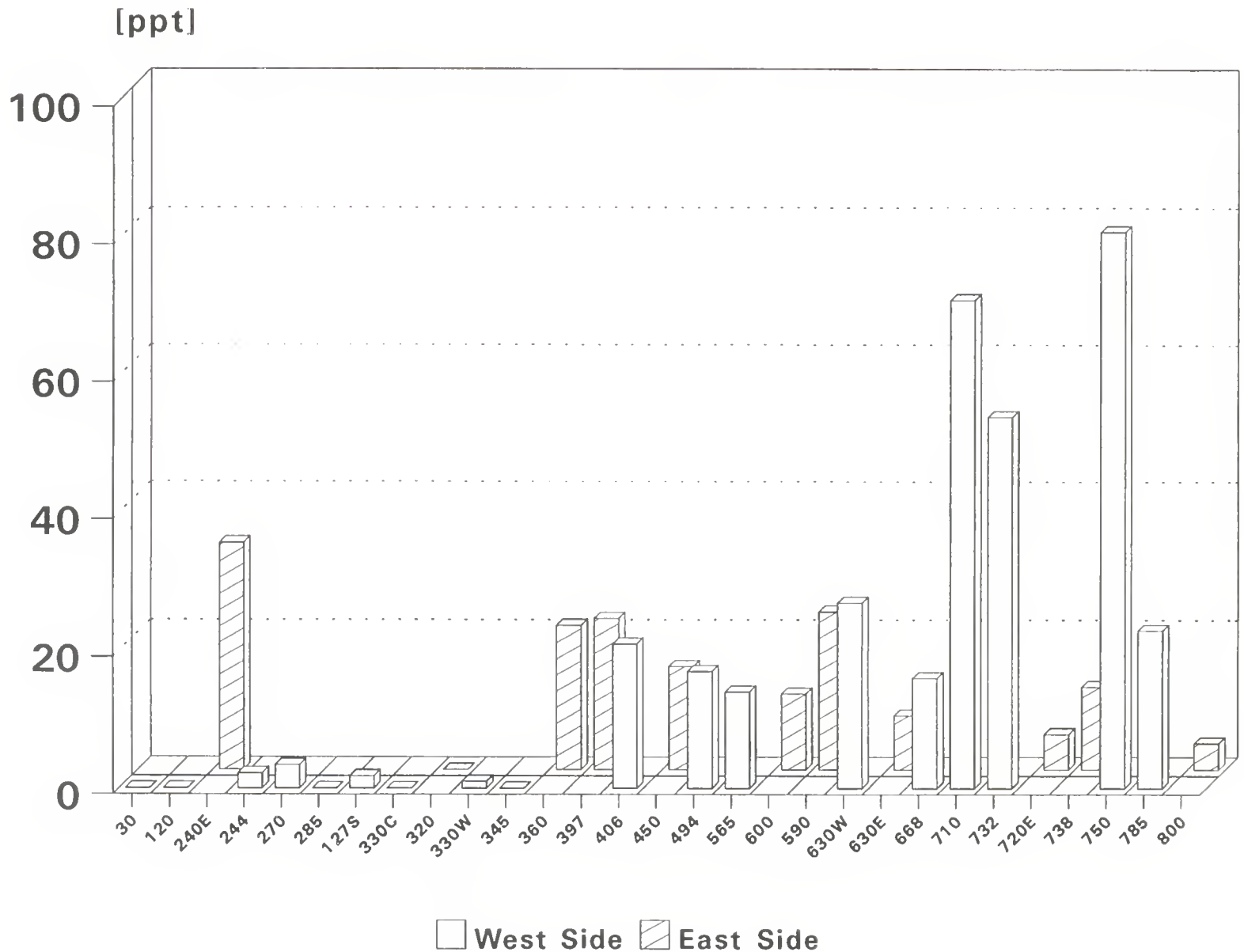


Figure 9: 2,3,7,8-TCDD in Sediment Cores

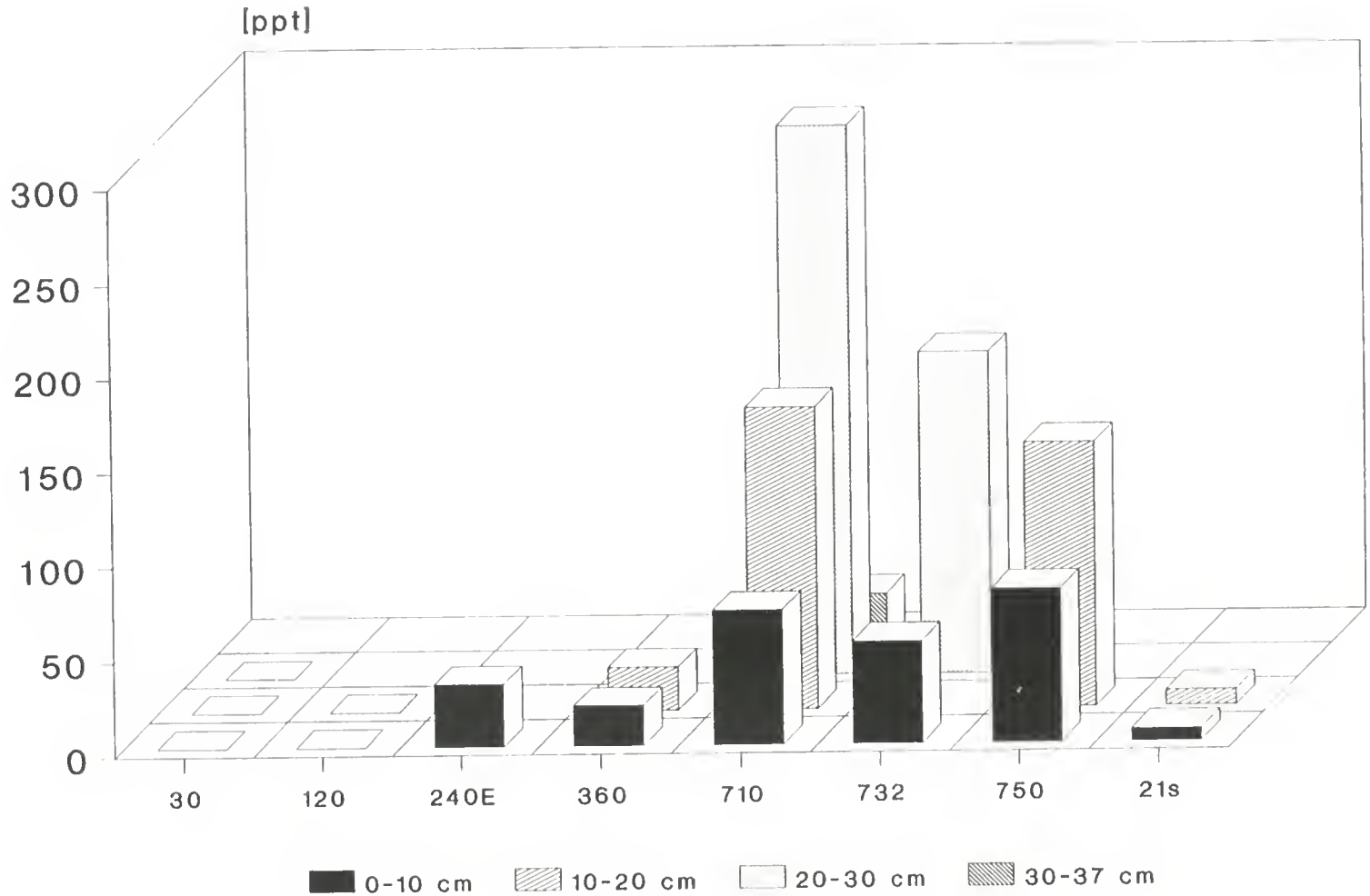


Figure 10: DDT in Bank Sediments

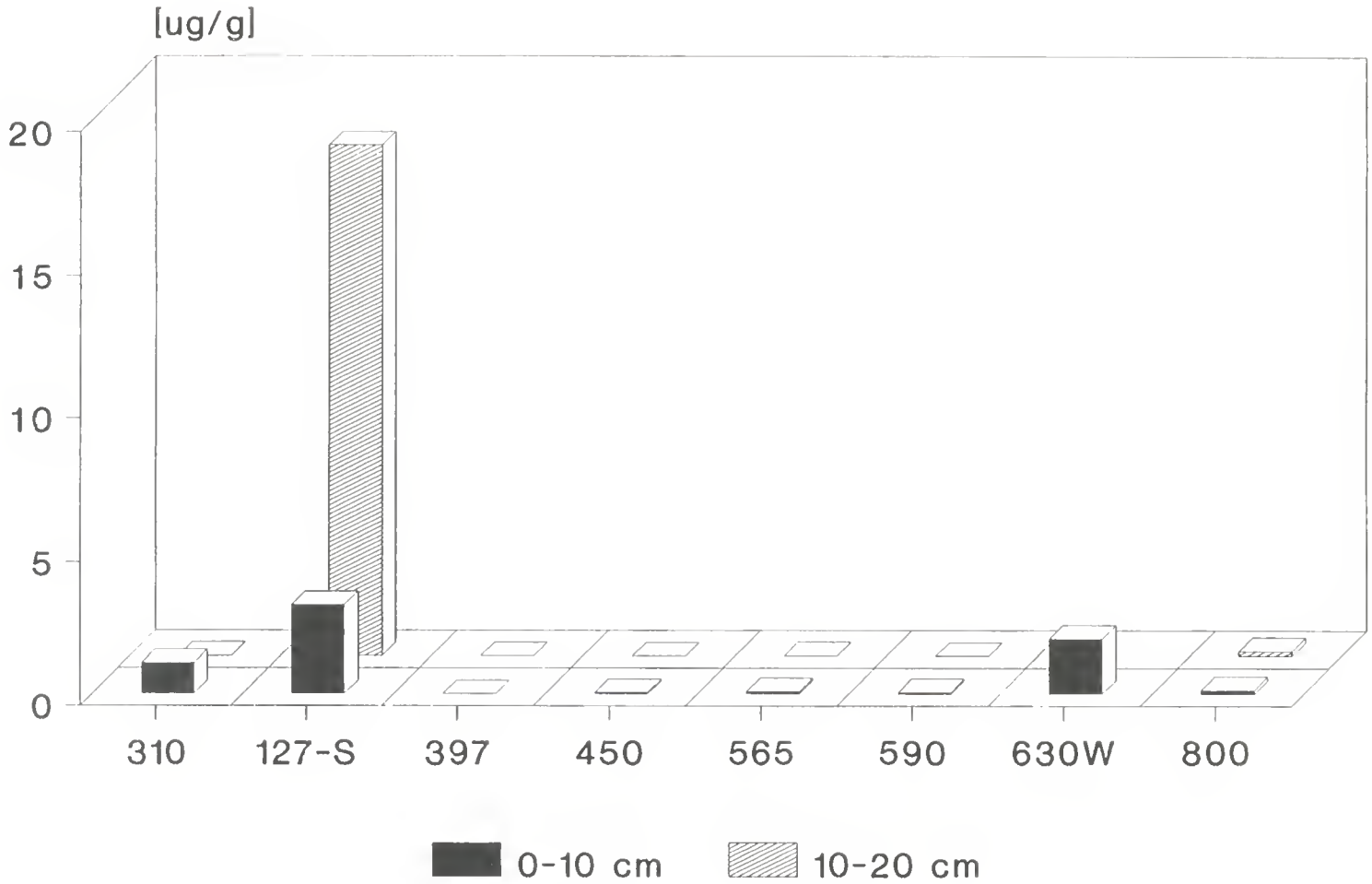


Figure 11: DDE in Bank Sediments

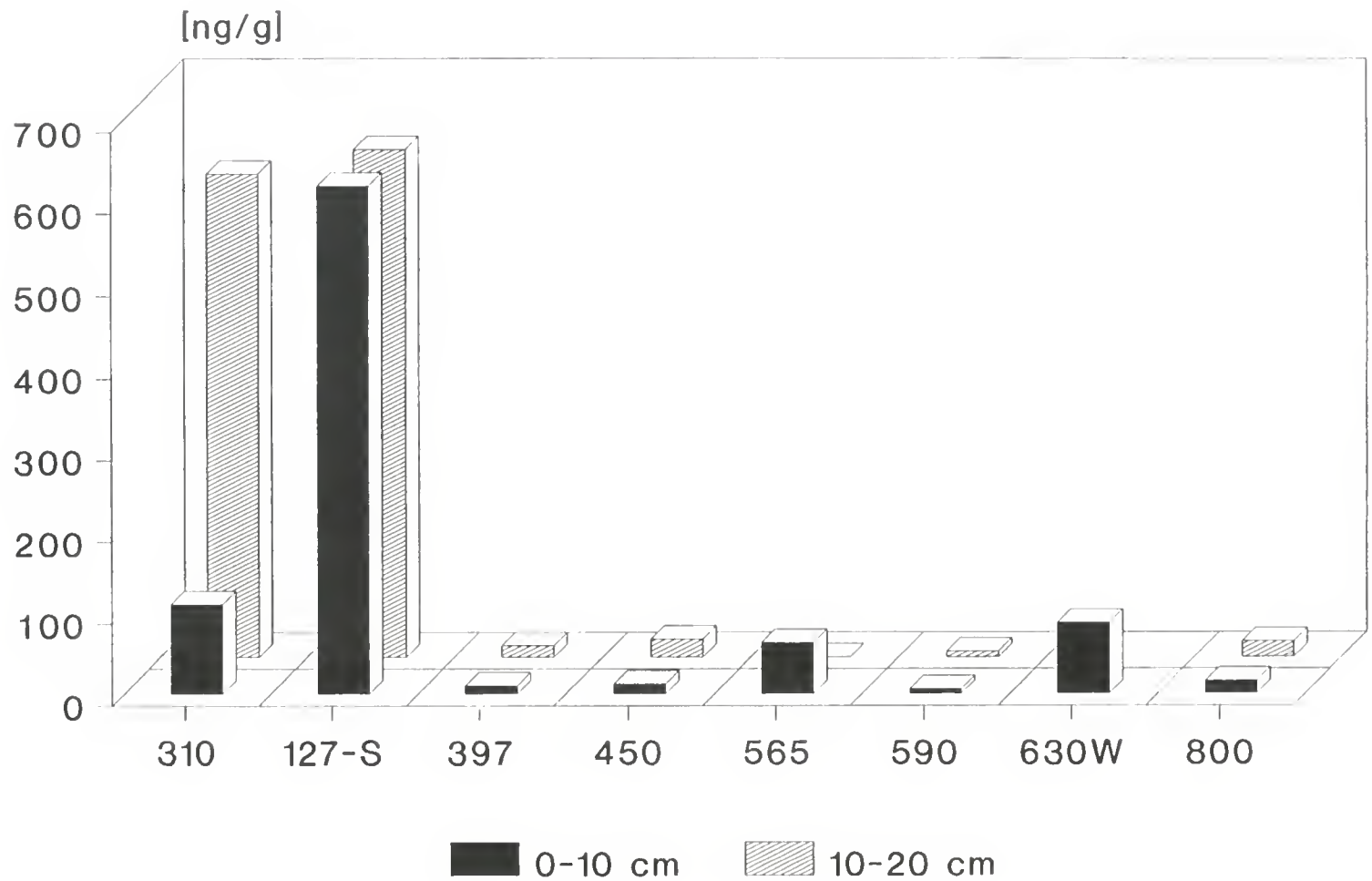


Figure 12: DDD in Bank Sediments

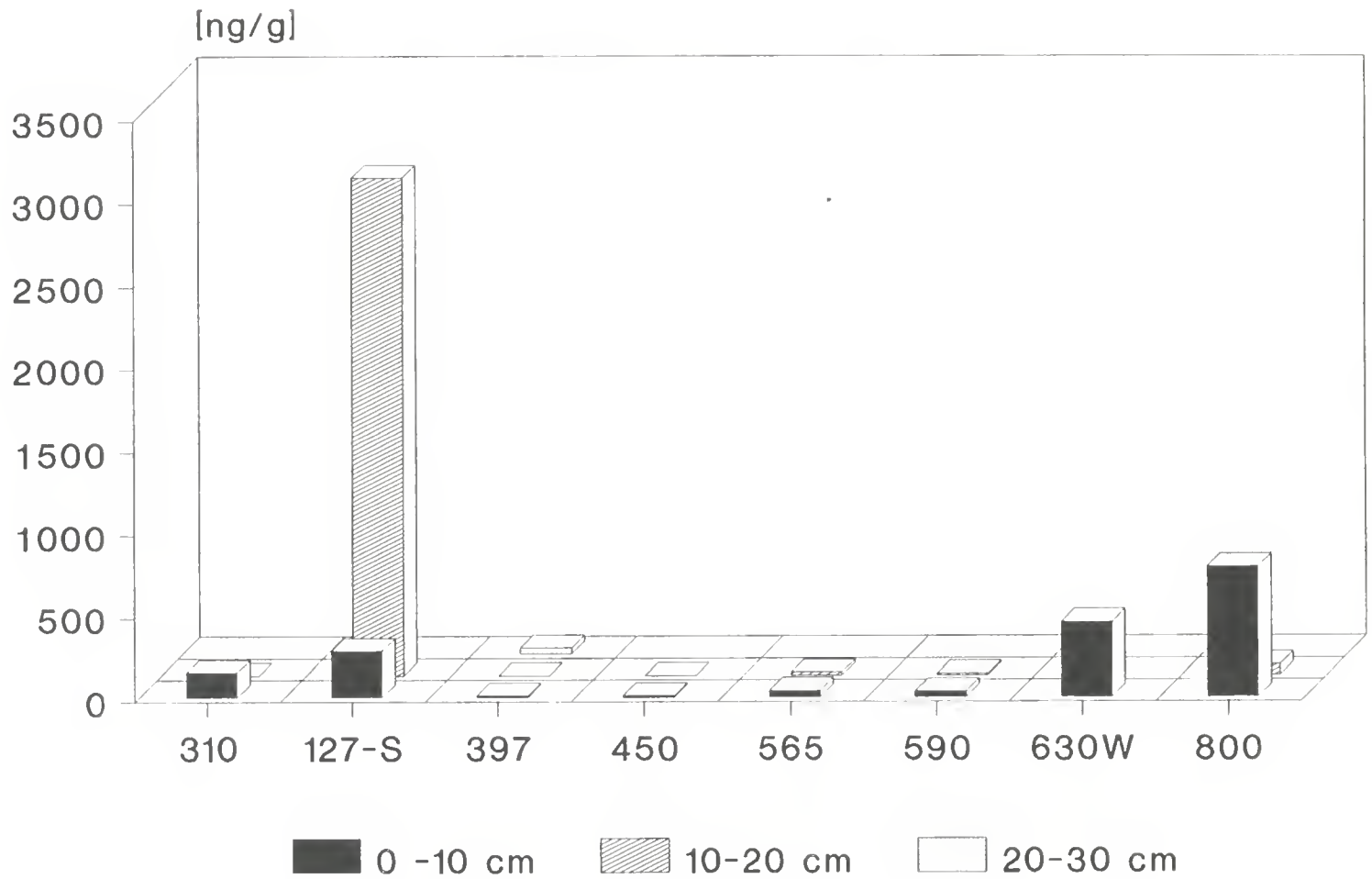


Figure 13: 2,3,7,8-TCDD in Bank Sediments and Soils

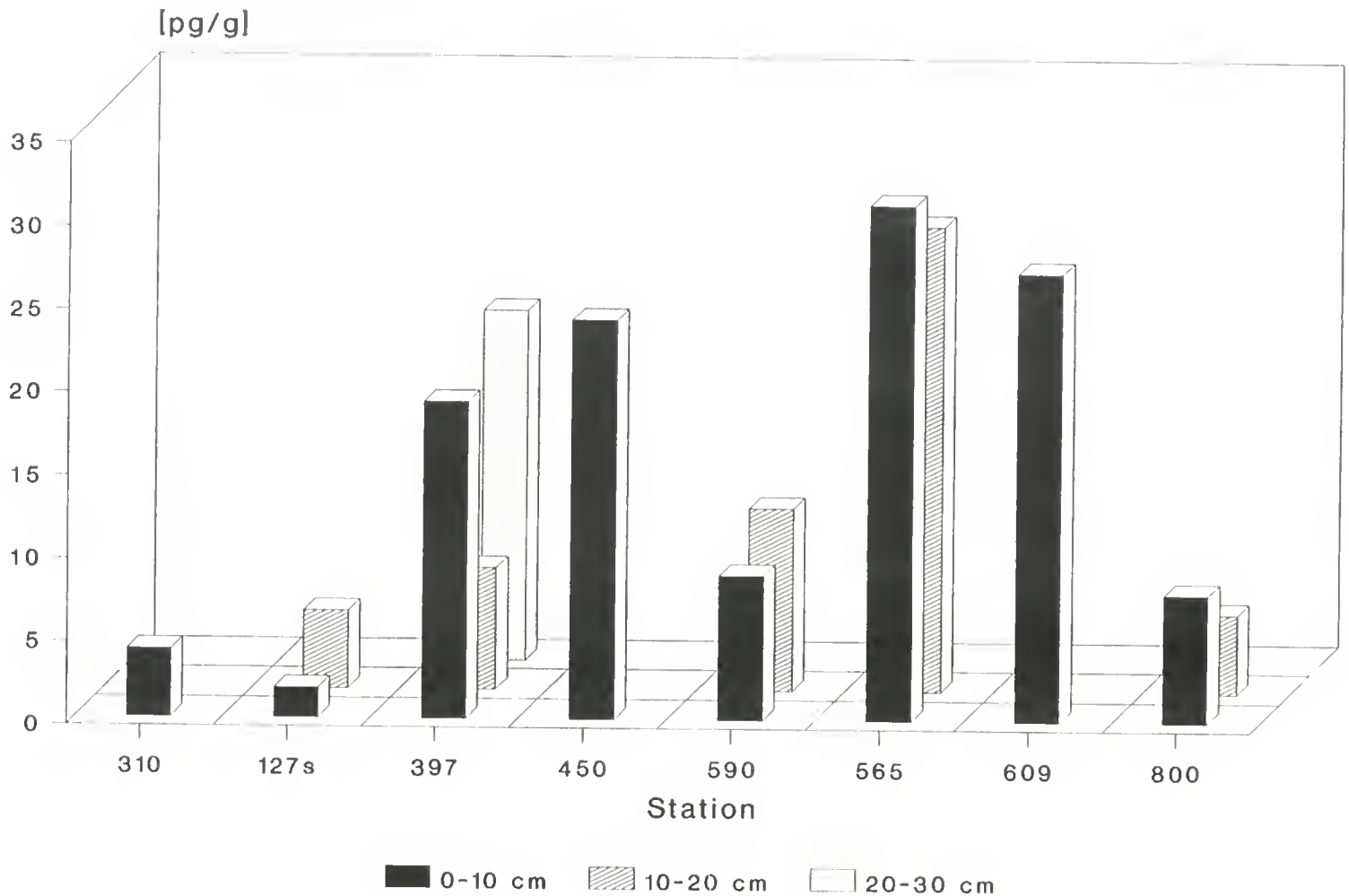


Figure 14: DDT and Metabolites in Floodplain Sediments

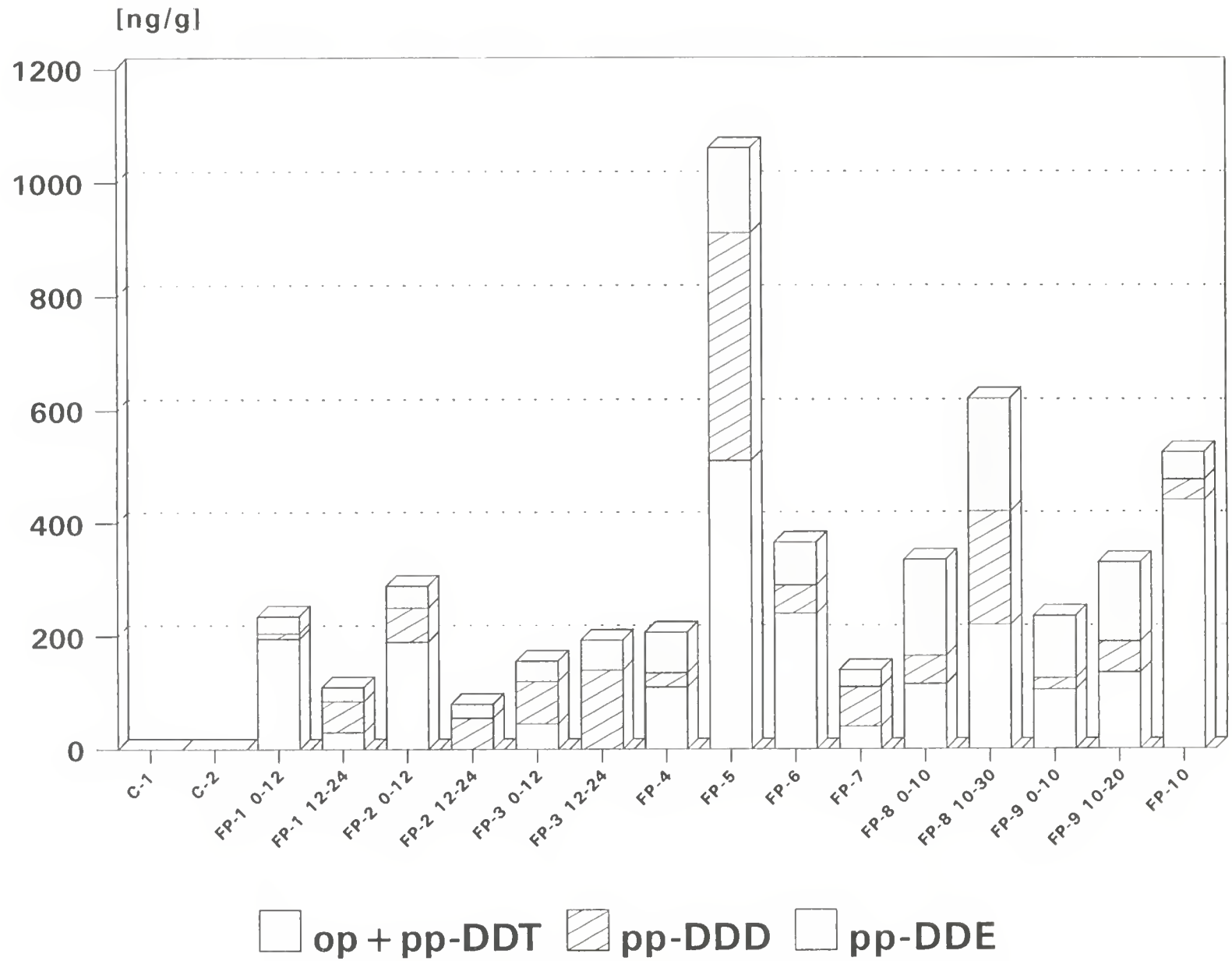


Figure 15: 2,3,7,8-TCDD in Floodplain Sediments

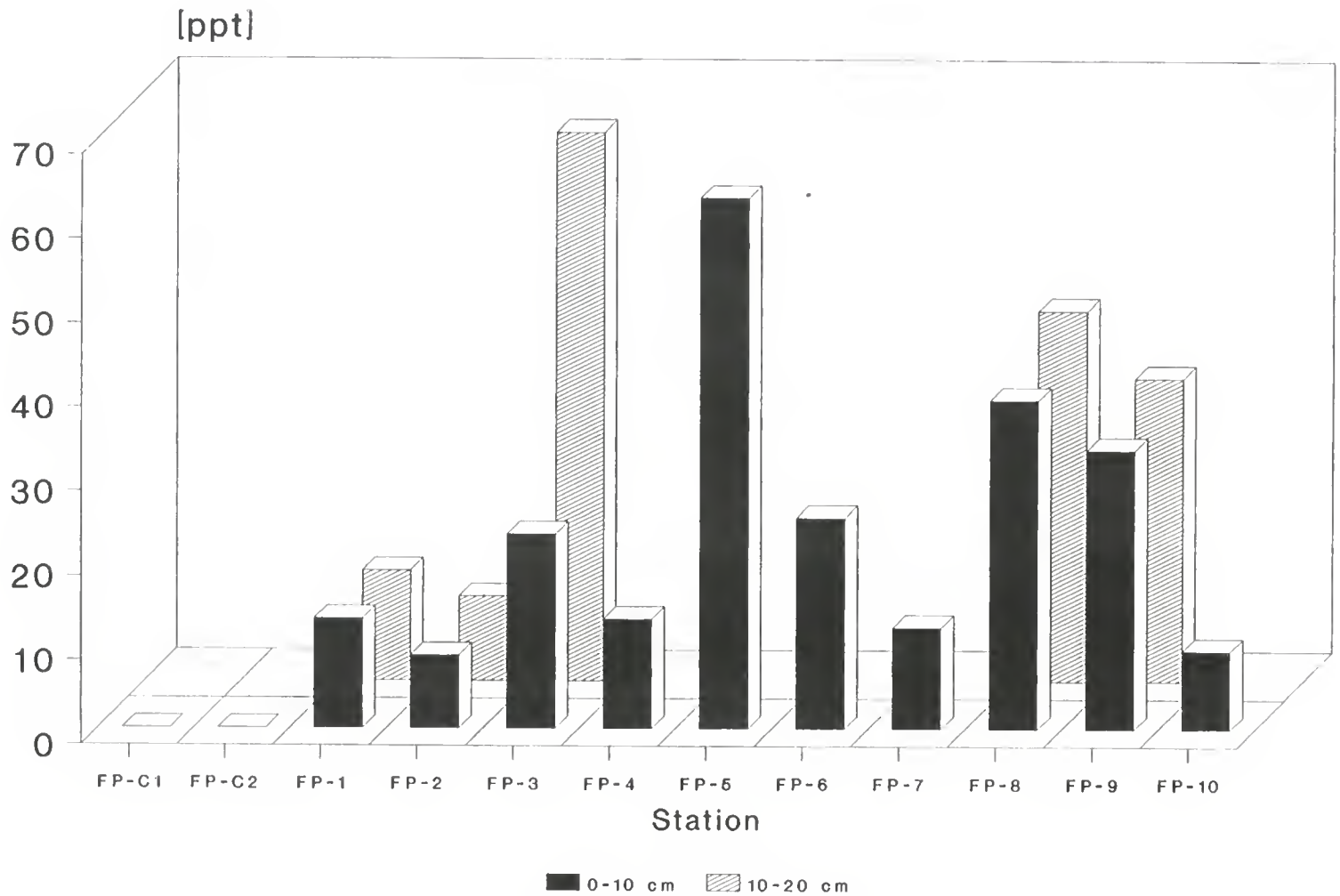


Figure 16: Distribution of Major Benthic Taxa

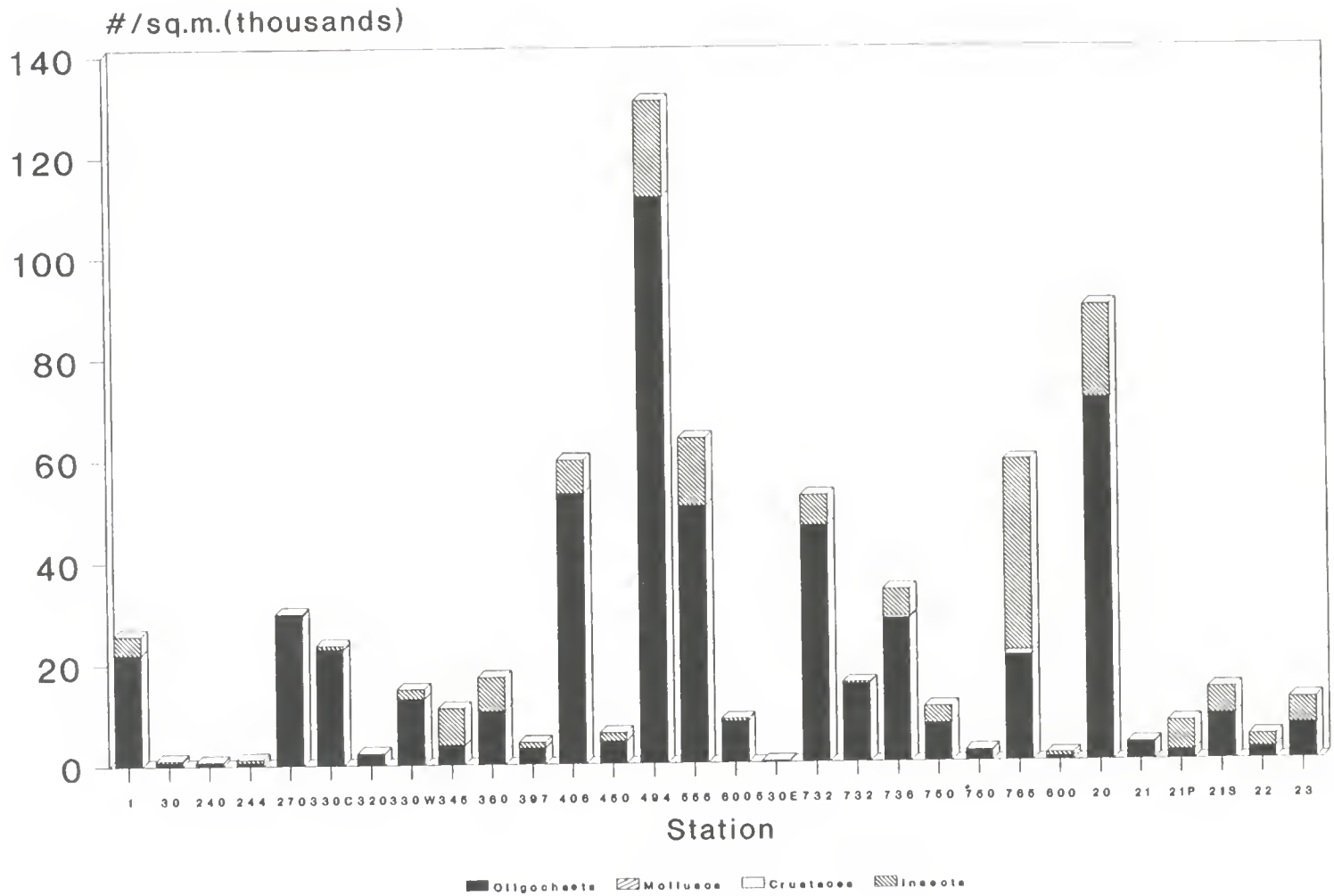
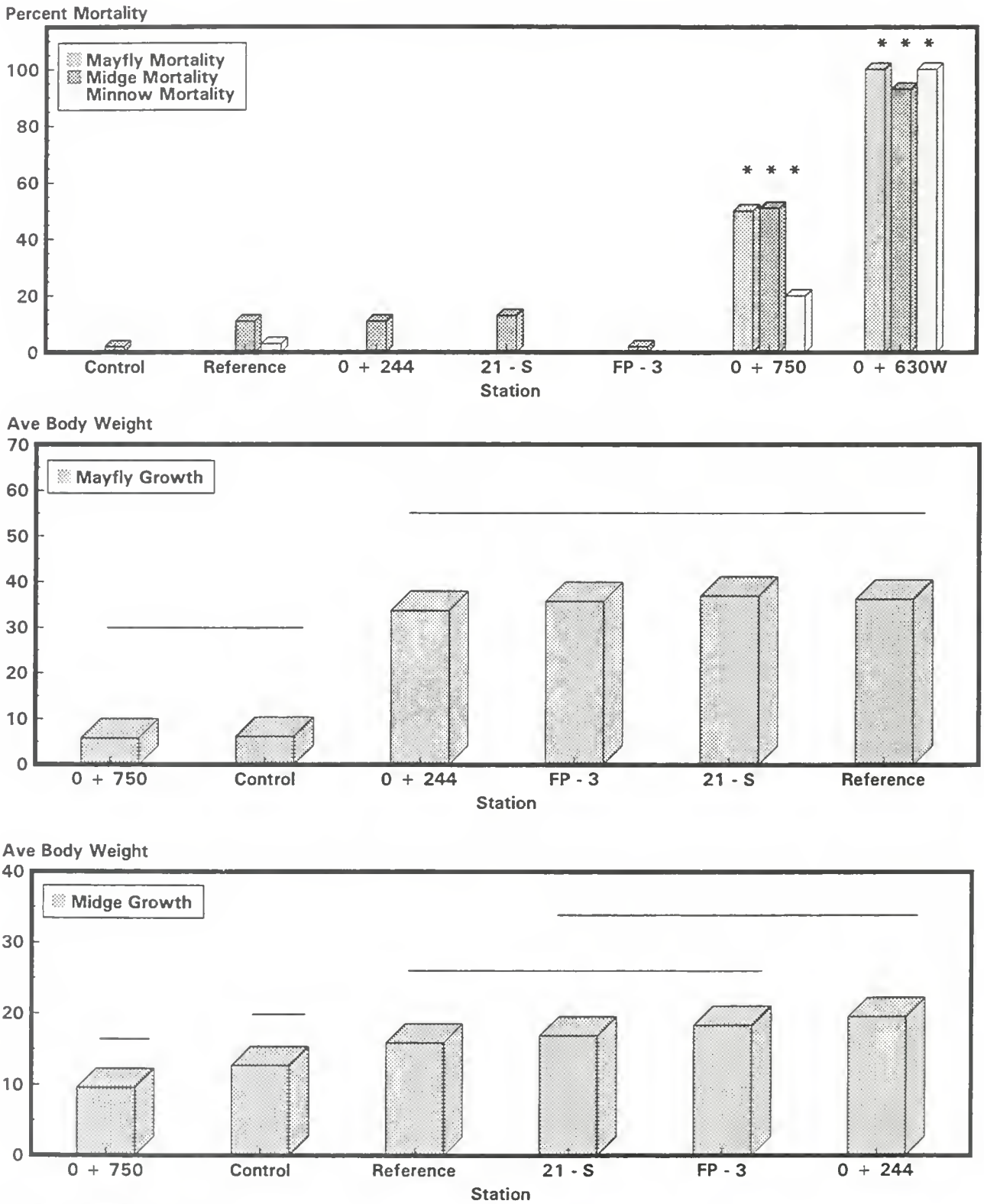


FIGURE 17. Organism mortality and growth in bioassay sediments



* significantly different than controls $p < 0.05$.
Lines indicate significant groups.

Figure 18: Concentrations of DDT and Metabolites in Sediment and Bank Samples (all concentrations in ppb.)

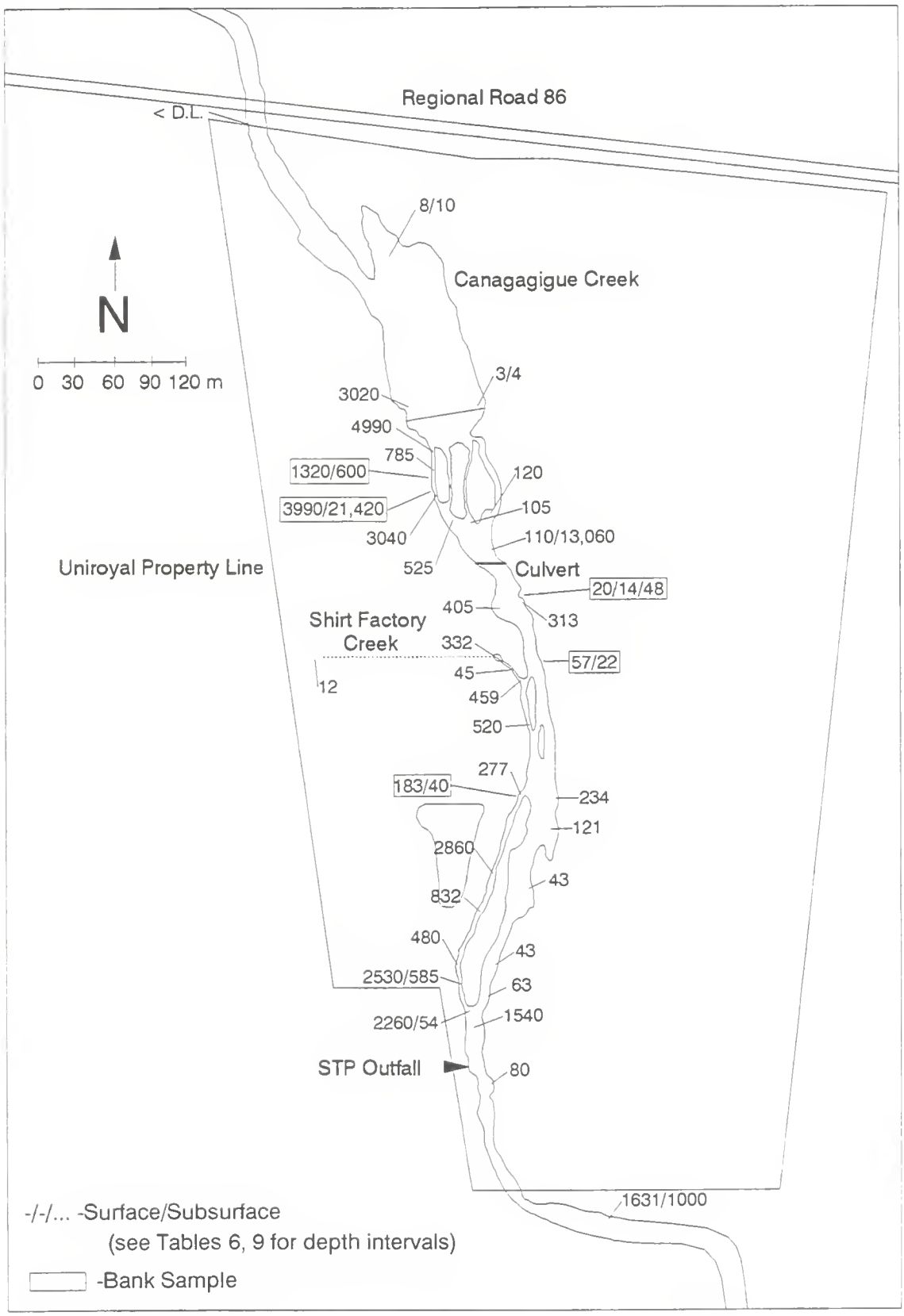


Figure 19: Concentrations of 2,3,7,8-TCDD in Sediment and Bank Samples
(all concentrations in ppt.)

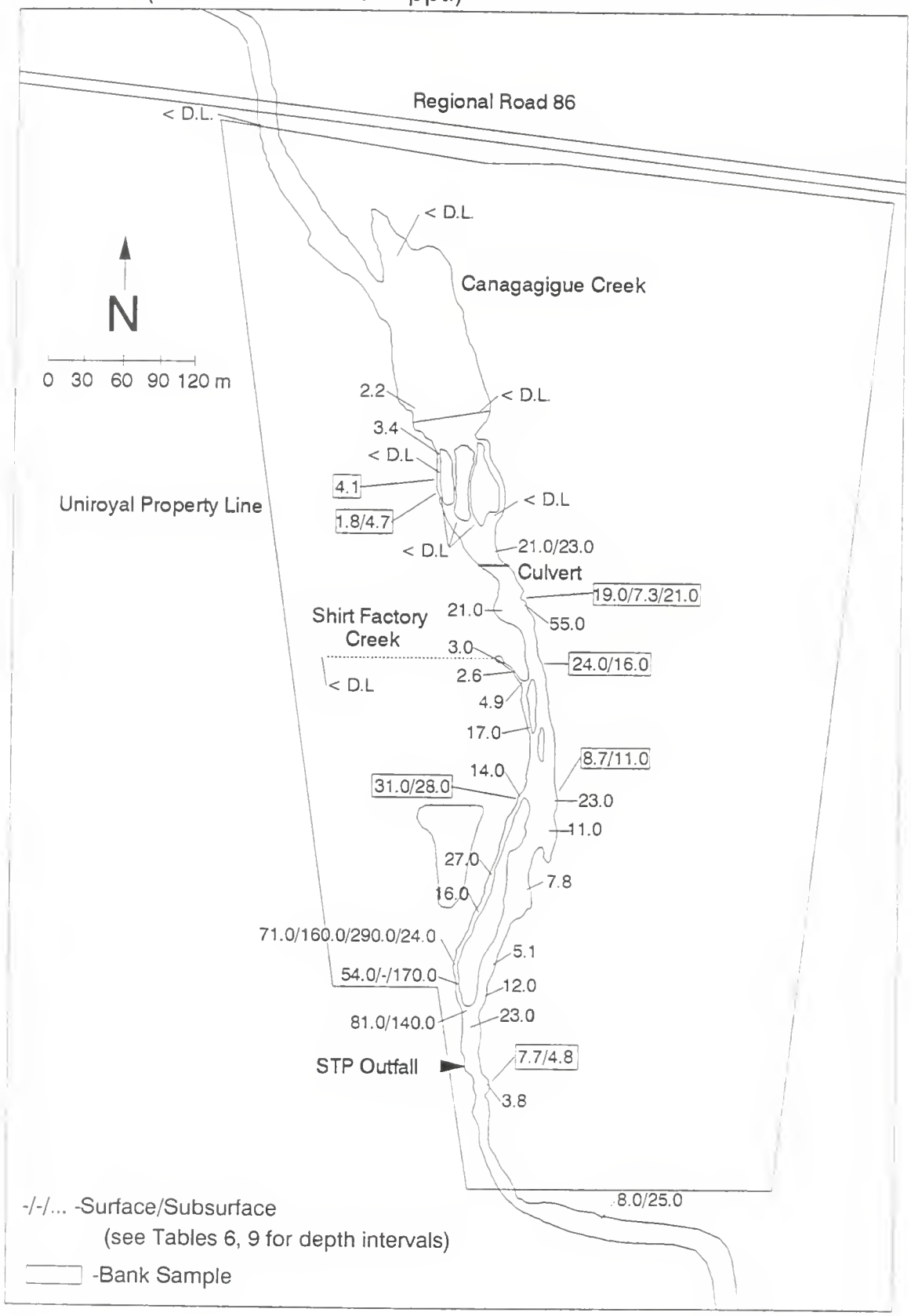


Figure 20: Concentrations of Total TEQ in Sediment and Bank Samples
(all concentrations in ppt.)

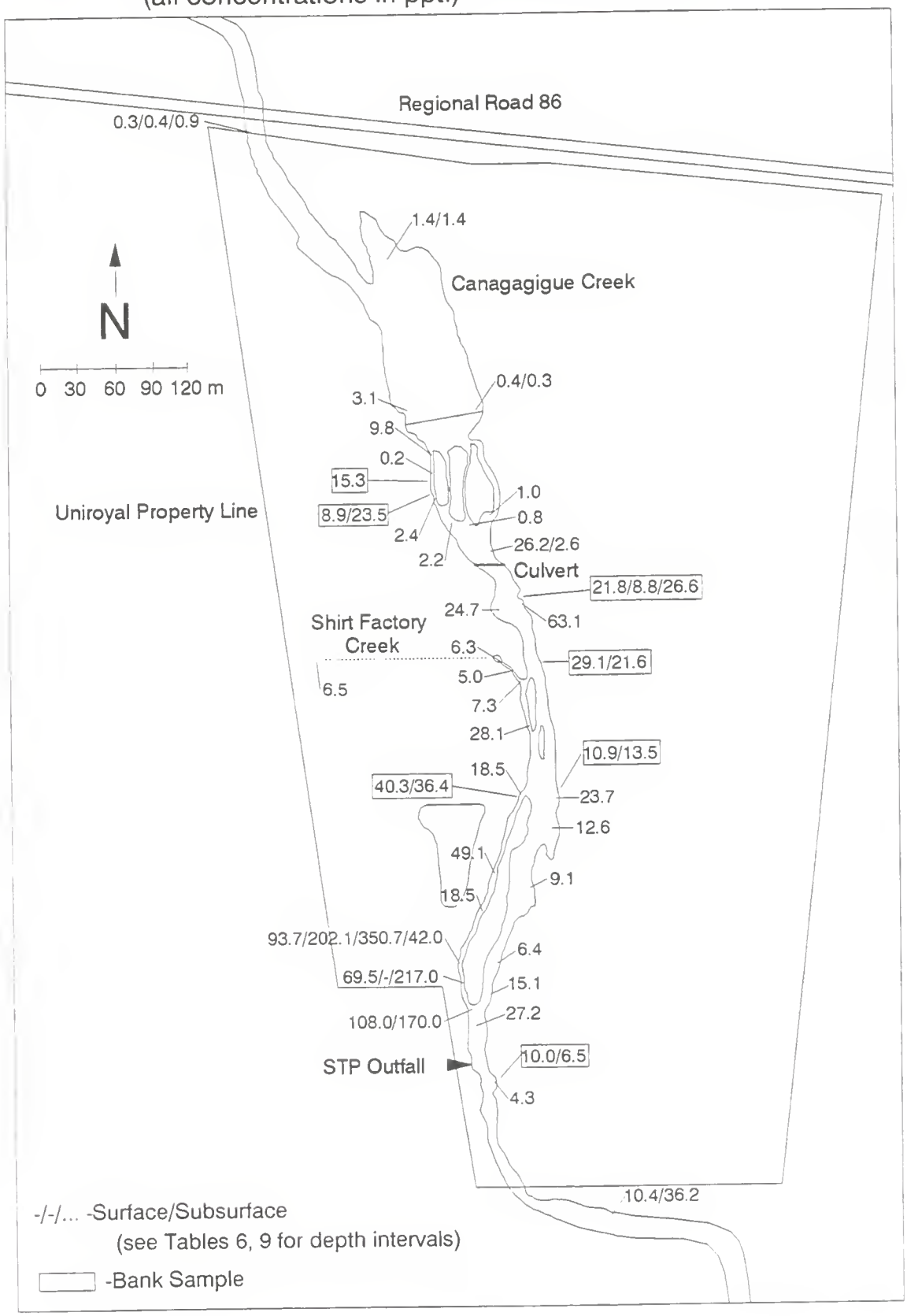


Figure 21: DDD and DDE as % Total DDT in Floodplain Sediments.

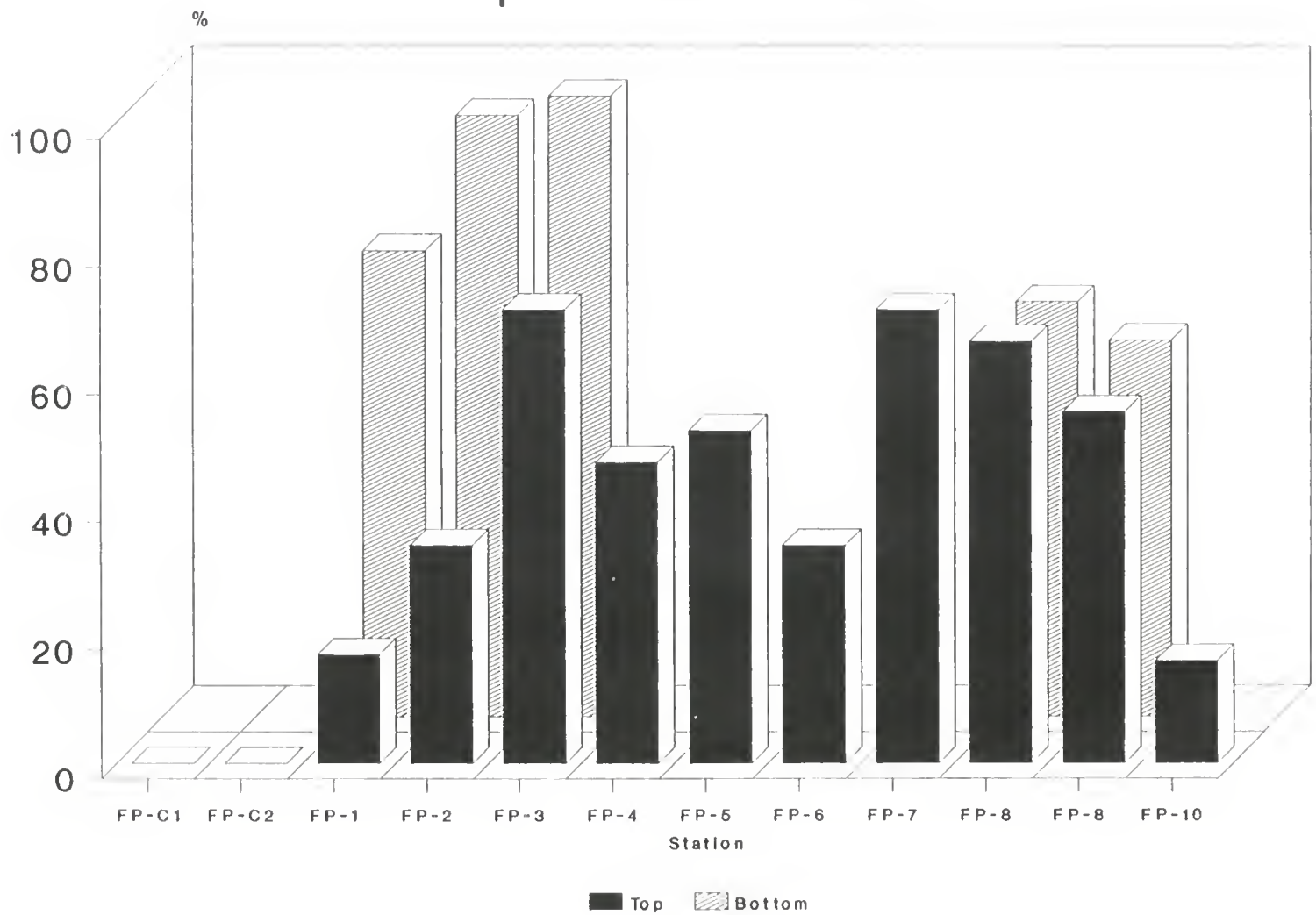


Figure 22: Distribution of 2,3,7,8-Substituted Isomers at Different Sampling Locations

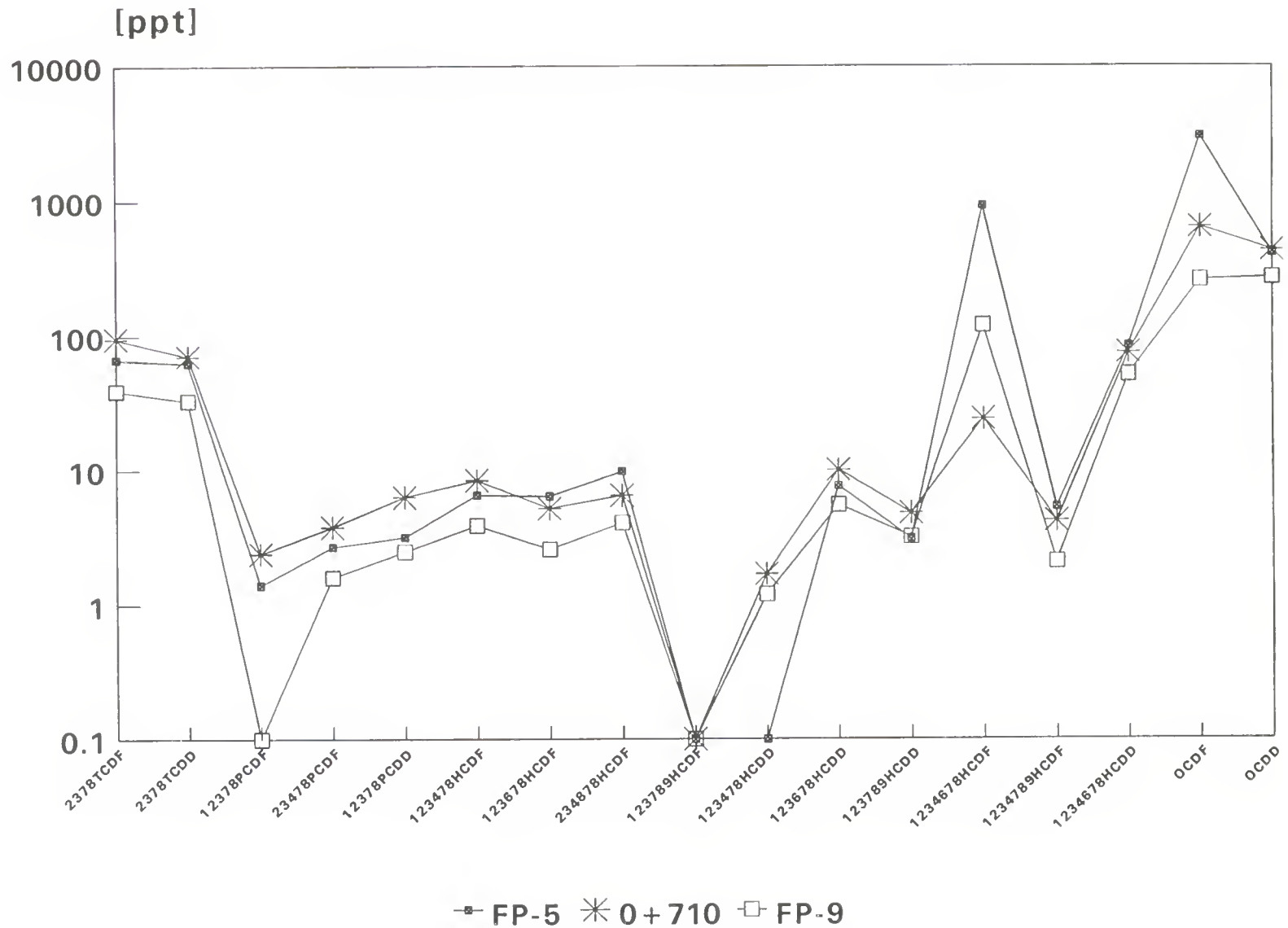


Figure 23: 2,3,7,8-TCDD in Sediments and Biota

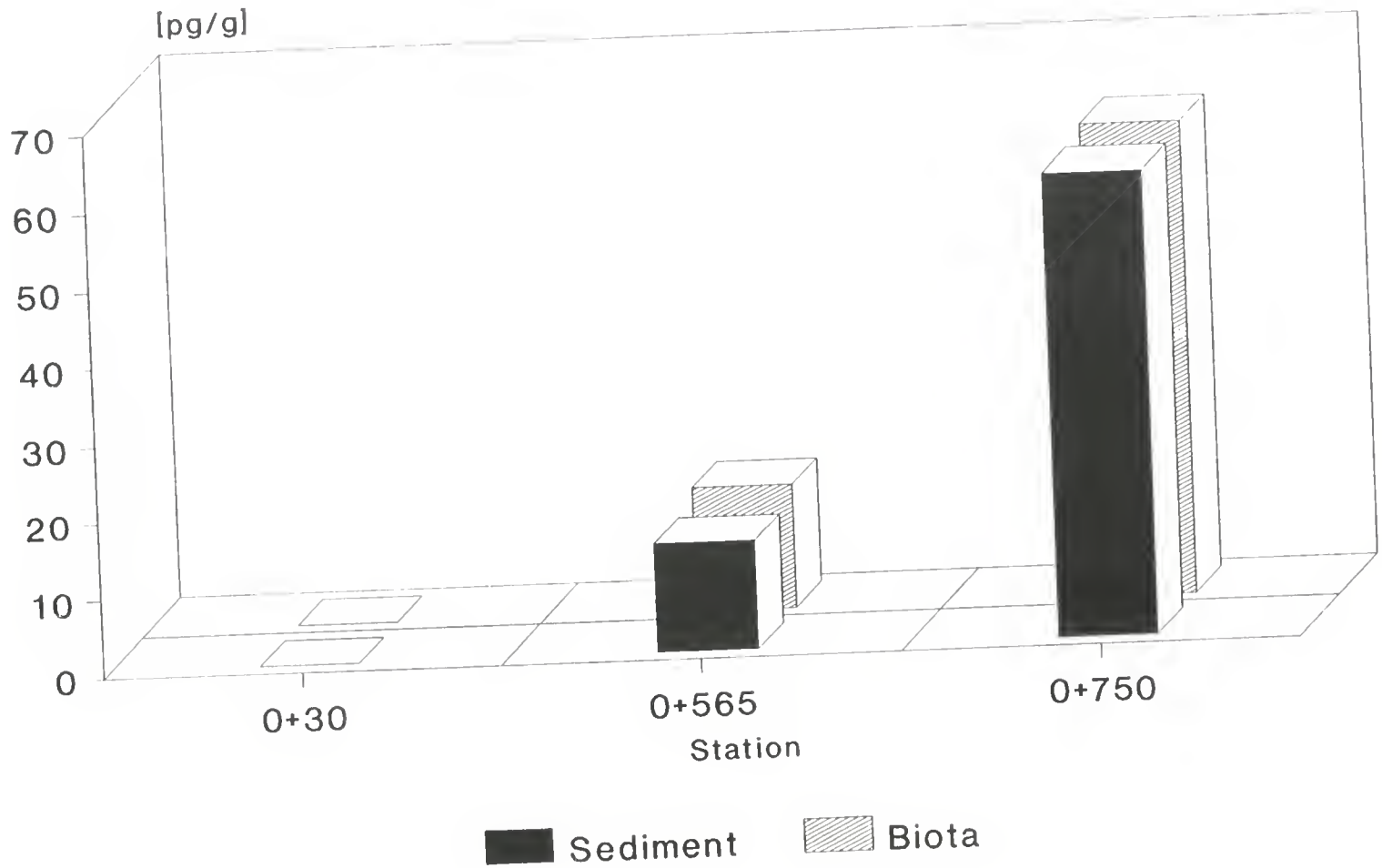


Figure 24: Biota-Sediment Accumulation Factors

Station 0 + 565

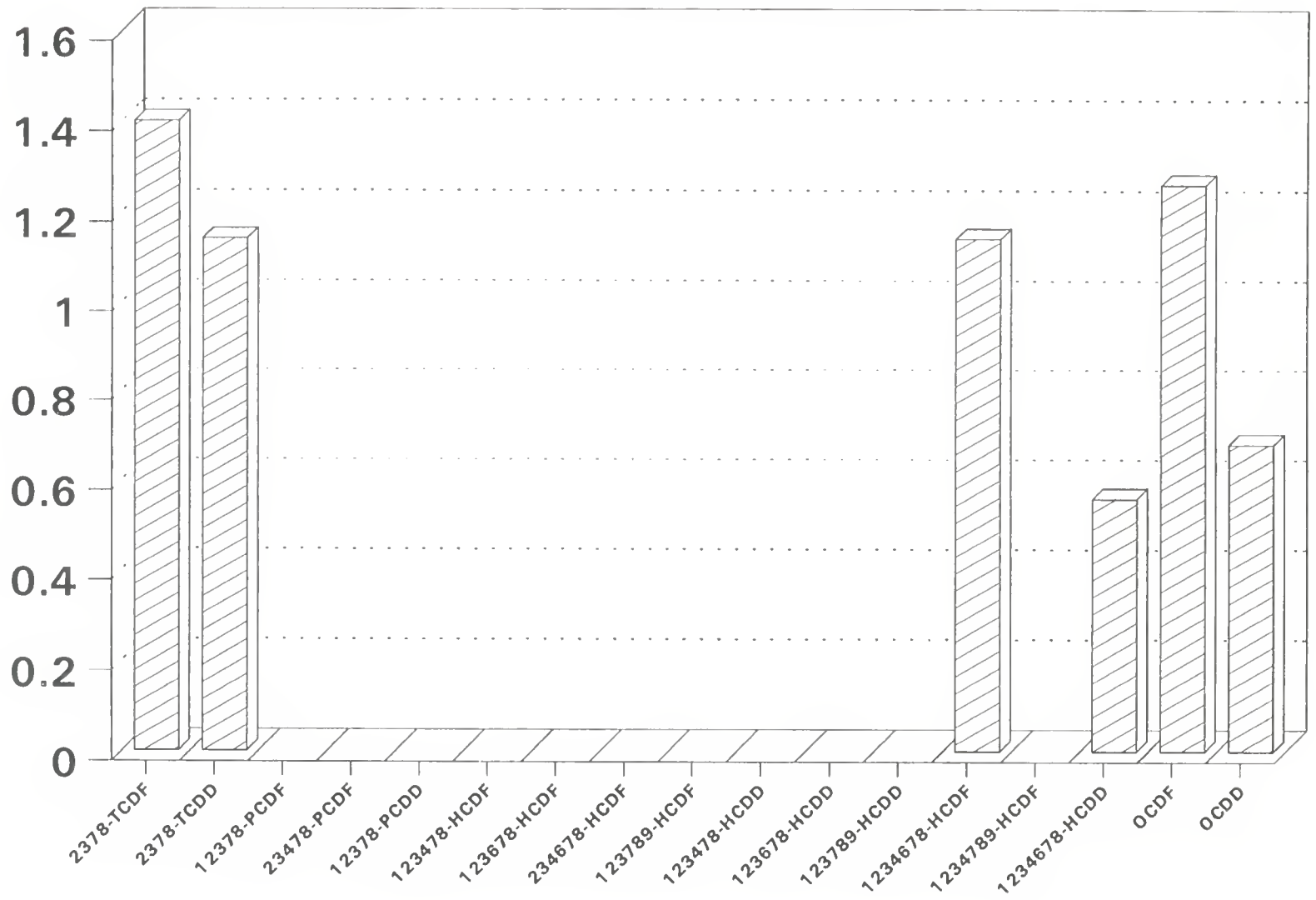


Figure 25: Biota-Sediment Accumulation Factors

Station 0 + 750

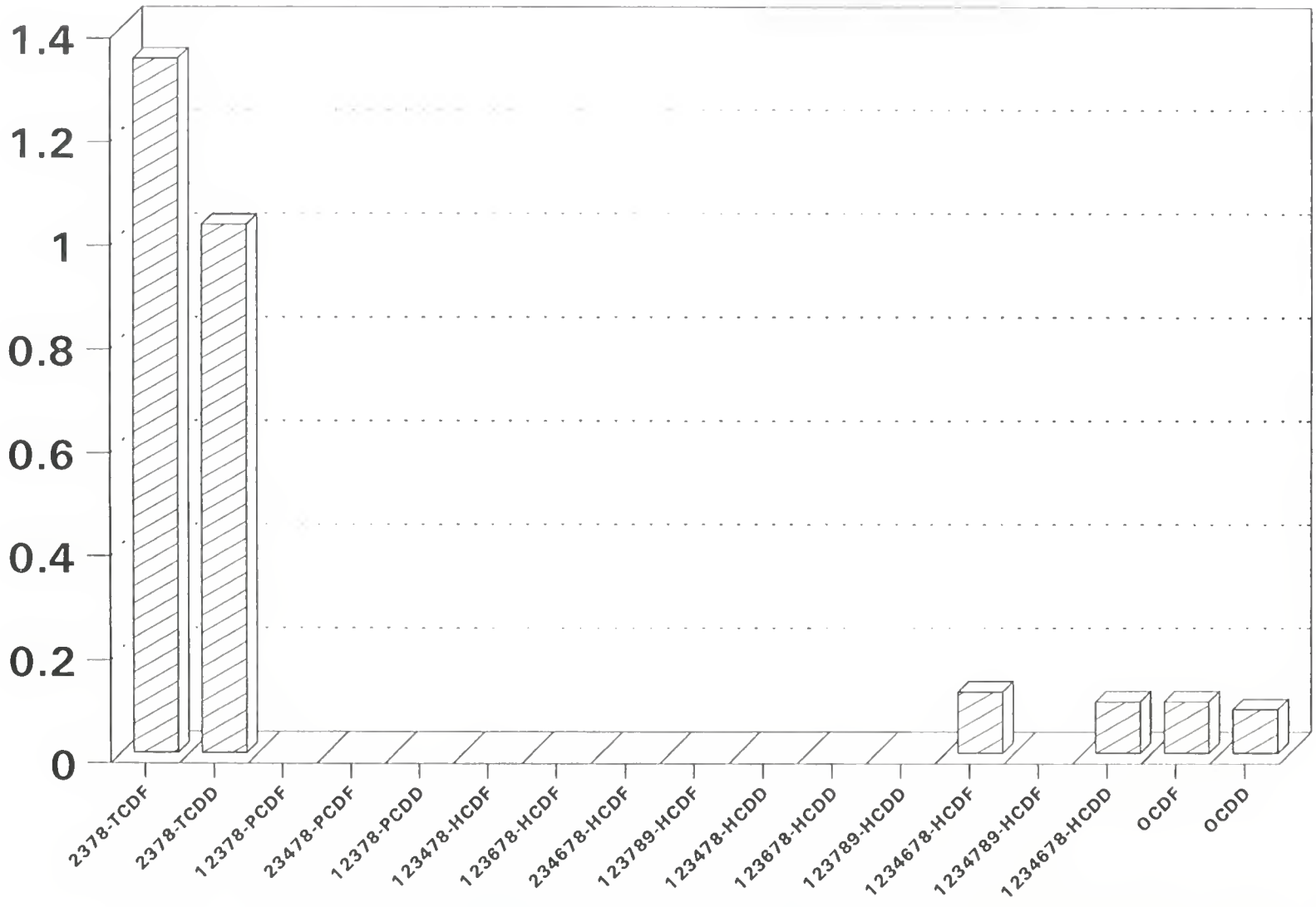
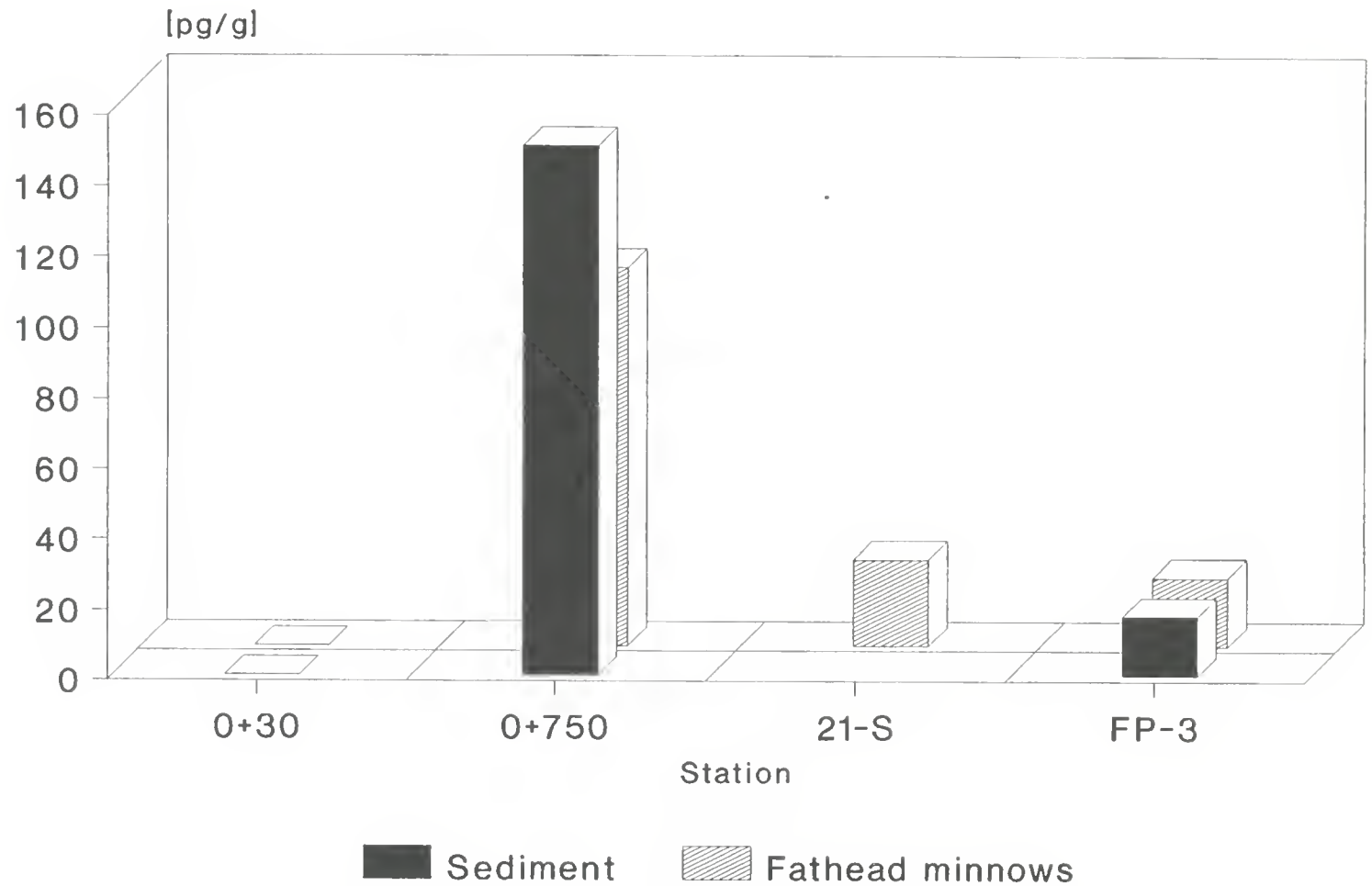


Figure 26: 2,3,7,8-TCDD in Sediments and Minnows



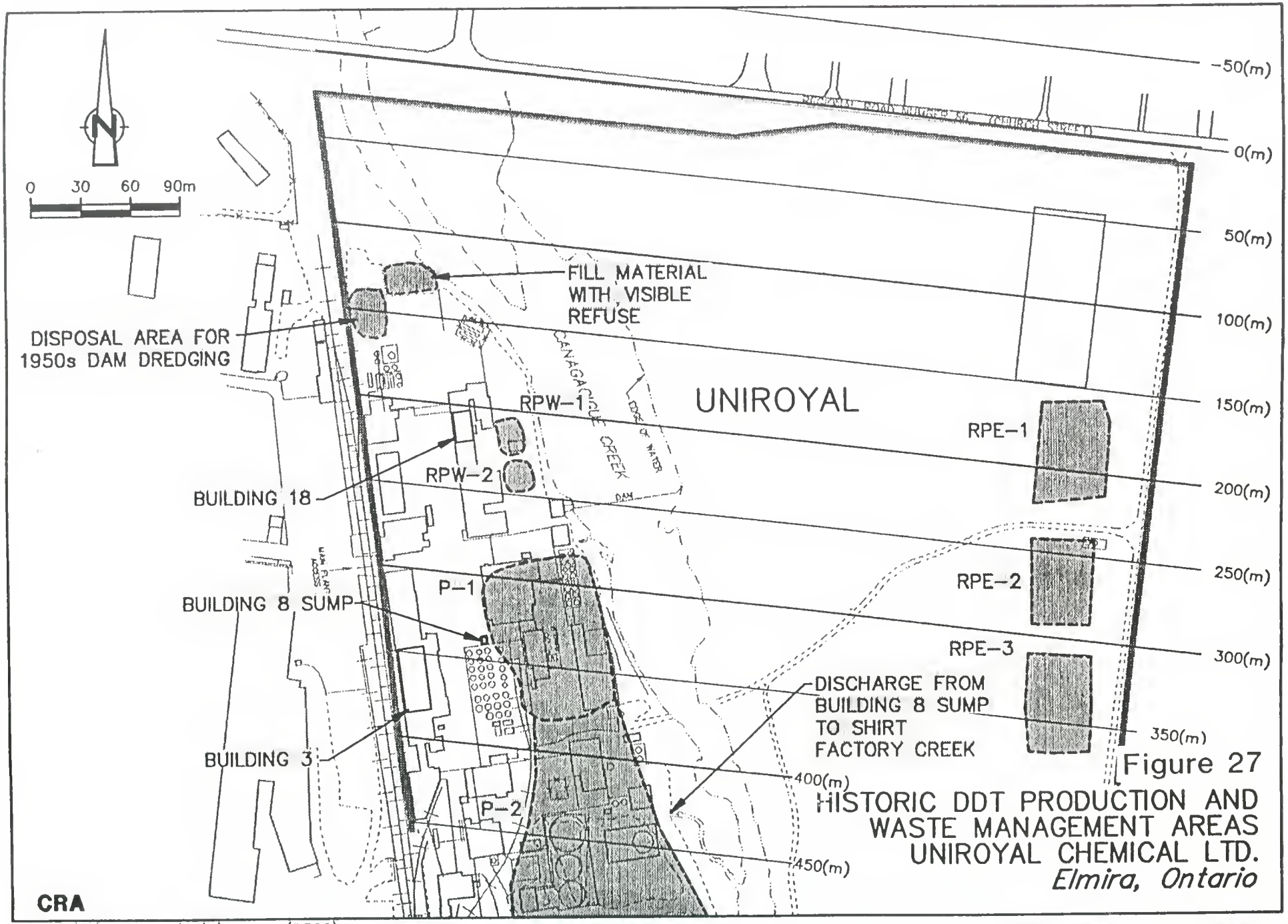


Figure 27

HISTORIC DDT PRODUCTION AND WASTE MANAGEMENT AREAS
UNIROYAL CHEMICAL LTD.
Elmira, Ontario